TNO Defence, Security and Safety

Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek / Netherlands Organisation for Applied Scientific Research

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TNO-report

TNO-DV1 2004 A169

The role of IMAT solutions for training development at the Royal Netherlands Air Force.

IMAT Follow-up Research Part I

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DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

Classification	Ongerubriceerd
Affiliation	KLu
Project officer	Dr. W.F.S. Hylkema
Classification date	29-08-2005
Title	Ongerubriceerd
Managementuittreksel	Ongerubriceerd
Abstract	Ongerubriceerd
Report text	Ongerubriceerd
Appendices	Ongerubriceerd
Contract no	-
Sponsor	KLu
Affiliation	
Project name	IMAT-2
Project number	015.32801
Copy no	6
No of copies	18
No of pages	114 (incl. Appendices, excl. RDP & distribution list)
No of appendices	1

Netherlands Organisation for Applied Scientific Research (TNO)

AQ F06-07-6428

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TNO-rapportnummer
TNO-DV1 2004 A169
Opdrachtnummer
-

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Rubricering rapport
Ongerubriceerd

Probleemstelling

De KLu heeft van 1998 tot 2001 deelgenomen aan het Europese IMAT (Integrating Manuals And Training) project (Esprit 29175). Daarna heeft de KLu aan TNO opdracht gegeven voor IMAT vervolgonderzoek. Het Europese IMAT project heeft een geavanceerde set van (prototype) tools opgeleverd om technische handleidingen efficiënt en effectief te kunnen hergebruiken voor het ontwikkelen van lesmateriaal.

Voor het IMAT vervolgonderzoek zijn de volgende doelstellingen geformuleerd:

1. Het verkrijgen van inzicht in de bruikbaarheid van de IMAT tools voor technische trainingsontwikkeling voor andere/nieuwe KLu-domeinen;
2. Vaststellen van mogelijke manieren waarop het IMAT concept een bijdrage kan leveren aan opleiding en training binnen de KLu;
3. Vaststellen hoe de IMAT metadata zich verhouden tot de door de KLu gehanteerde ADL-SCORM standaard en daarop gebaseerde tools ter ondersteuning van het ontwikkelen van lesmateriaal;
4. Opbouwen en verspreiden van IMAT kennis binnen de KLu en TNO.

Beschrijving van de werkzaamheden

Om doelstelling 1 te kunnen beantwoorden is een IMAT tools analyse uitgevoerd met als doel inzicht te verwerven in specifieke uitdagingen voor de KLu in het geval gekozen wordt voor het in gebruik nemen van de tools. Om doelstelling 2 te kunnen beantwoorden is een contextanalyse uitgevoerd, gericht op Educatieve, Technologische en Onderwijskundige (ETO) factoren binnen de KLu. Op basis van deze ETO factoren zijn proces- en specificatiemodellen ontwikkeld voor het implementeren van het IMAT concept en tools. De verzamelde factoren en ontwikkelde modellen zijn gevalideerd door middel van twee expert interviews. Om meer inzicht te krijgen in de toepasbaarheid van IMAT oplossingen voor (technische) trainingsontwikkeling bij de KLu zijn vervolgens diverse gebruiksscenario's ontwikkeld en geëvalueerd middels expert reviews. Ten behoeve van doelstelling 3 heeft er een vergelijking plaatsgevonden tussen de IMAT en ADL-SCORM metadata en is een mogelijke combinatie van IMAT en de op ADL-SCORM gebaseerde tool ter ondersteuning van het ontwikkelen van lesmateriaal is onderzocht. Voor doelstelling 4 zijn een aantal IMAT presentaties/colloquia gehouden en is een IMAT workshop uitgevoerd.

Bovenstaande werkzaamheden zijn beschreven in twee rapporten ('IMAT follow-up research part I' en 'part II'). Dit rapport beschrijft de tools- en de context analyse. Rapport II beschrijft de scenario ontwikkeling en de expert review. De resultaten van de werkzaamheden leiden tot gezamenlijke conclusies die zijn opgenomen in beide rapporten.

Resultaten en conclusies

Op basis van de in dit project uitgevoerde analyse kan worden geconcludeerd dat het IMAT concept een waardevolle bijdrage kan leveren aan opleiding en training binnen de

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KLu. De huidige IMAT tools zijn echter, ondanks de zeer vergevorderde status, prototype tools die verder (her)ontwikkeld moeten worden om als volledig operationele tools te kunnen worden ingezet. Of dit zinvol is voor de KLu, zal afhangen van keuzes die de organisatie maakt m.b.t. het ontwikkelen van elektronisch lesmateriaal, aard en omvang van het trainingsdomein, maar ook van andere zaken die hierop van invloed zijn, zoals,bijvoorbeeld ,de invoering van elektronische technische manuals en de Joint Aviation Regulations. Het onderzoek heeft daarnaast geresulteerd in een set van randvoorwaarden/eisen voor IMAT oplossingen enerzijds en de KLu organisatie anderzijds voor een succesvolle IMAT implementatie. Ook is een stappenplan opgesteld om, desgewenst, de IMAT tools verder te ontwikkelen.

Toepasbaarheid

Indien de IMAT tools niet verder worden ontwikkeld, kan de KLu gebruik maken van IMAT concepten en kennis bij andere opleidingstrajecten waar elektronisch lesmateriaal wordt (her)gebruikt. Bovendien kunnen sommige IMAT tools, zoals, bijvoorbeeld, de Instructional Scenarios Tool (die didactische ondersteuning biedt bij het ontwikkelen van elektronisch lesmateriaal), ook worden ingezet als aparte tool. Indien de KLu overweegt om de IMAT tools verder te ontwikkelen kunnen de rapporten van het IMAT vervolgonderzoek als basis dienen voor het opstellen van IMAT specificaties.

PROGRAMMA	**PROJECT**
Programmabegeleider Dr. W.F.S. Hylkema, KLu	Projectbegeleider Dr. W.F.S. Hylkema, KLu
Programmaleider Dr.ir. H. Kuiper, TNO	Projectleider Dr.ir. H. Kuiper, TNO
Programmatitel Geavanceerde training- en opleidingsconcepten	Projecttitel IMAT-2
Programmanummer V907	Projectnummer 015. 30801
Programmaplanning Start 01-01-2000 Gereed 31-12-2003	Projectplanning Start 01-10-2001 Gereed 31-12-2003
Frequentie van overleg Met de programma/projectbegeleider werd meerdere malen gesproken over de invulling en de voortgang van het onderzoek.	Projectteam Dr.ir. H. Kuiper (TNO) Mevr. Drs. L.R.M.A. Jacobs (TNO) Mevr. Dr. D.M.L. Verstegen (TNO) Mebr. Drs. N.H.E. Janssen (TNO)

Contents

Abbreviations

ADL	Advanced Distributed Learning
AIDAS	Amsterdam Intelligent Document Analysis System
ATTP	Avionics Technical Training Package
CBT	Computer Based Training
CML	Conceptual Modeling Language
DAS	Document Analysis System (file)
EPAF	European Air Forces
ETM	Electronic Technical Manual
ETO	Educational, Technical and Organisational (factors)
GGW	Groep Geleide Wapens
HTML	Hyper Text Mark up Language
IETM	Interactive Electronic Technical Manual
ICT	Information & Communication Technology
IMAT	Integrating Manuals and Training
IMI	Interactive Multimedia Instruction
IPI	In-Process Inspection
ITOD	International Technical Order Digitisation
ISLA	Intelligent Systems Laboratory Amsterdam
JAA	Joint Aviation Authorisation
JAR	Joint Aviation Regulations
JE	Just Enough
JIT	Just In Time
KLUIM	Koninklijke Luchtmacht Implementatie Middenlaag
KMSL	Koninklijke Militaire School Luchtmacht
LAN	Local Area Network
LCMS	Learning Content Management System
LE	Luchtwaardigheidseisen/borging
LMS	Learning Management System
LOM	Learning Object Metadata
MTDS	Mission Training (through) Distributed Simulation
MTTP	Mechanical Technical Training Package
NATO	North Atlantic Treaty Organisation
OCR	Optical Character Recognition
PDF	Portable Document Format
RNLAF	Royal Netherlands Air Force
ROI	Return On Investment
SCO	Sharable Content Object
SCORM	Sharable Content Object Reference Model
SBT	Simulation Based Training
SME	Subject Matter Expert
SVG	Scalable Vector Graphics
TNO	The Netherlands Organisation for Applied Scientific Research

TM	Technical Manual
TT	Technical Training
ULT	Unit Level Trainer
XML	eXtensible Mark-up Language
WBT	Web Based Training
4CID	4 Components Instructional Design

1. Introduction

This report is the first IMAT report describing the work and results of the IMAT follow-up research conducted by TNO for the Royal Netherlands Air Force (RNLAF) from 2002 until 2003.

The purpose of the IMAT follow-up research is:

- To gain insight in the usability of IMAT concepts and prototype tools for use within the RNLAF;
- To determine how the IMAT approach can be exploited in the light of many other relevant training issues in the technical training domain;
- To determine how the IMAT meta-data relate to the ADL-SCORM standard and the SCO-Generator adopted by the RNLAF;
- To disperse IMAT knowledge further within the RNLAF and TNO;

This report (IMAT Follow-up Research Part I) describes the new domain implementation that was conducted to gain further insight in the usability issues of the latest version of the IMAT Pfinal tools. Next, the factors influencing the usability of IMAT concepts and tools in the RNLAF are described and an overview is given of factor and requirements models, which were developed to enhance thinking on future (IMAT) training development solutions for technical training in the RNLAF. Finally, the conclusions and recommendations for the future use of the IMAT concept and tools within the RNALF are presented, based upon the work as described in reports I and II of the IMAT follow-up research and the IMAT/ADL-SCORM report (Veerman, et al., 2002).

The second IMAT report (IMAT Follow-up Research Part II; Janssen, et al., 2004) elaborates further on possible future solutions that can be provided by IMAT concepts and tools through the development and expert review of various scenarios. This report also addresses the relations and implications between IMAT, ADL-SCORM and the SCO-Generator, the RNLAF's template-based authoring tool for the development of electronic training material. Finally, the conclusions and recommendations for the future use of the IMAT concept and tools within the RNLAF are presented, based upon the work as described in reports I and II on the IMAT follow-up research and the IMAT/ADL-SCORM report.

The structure of this report is as follows.

- Chapter 1 gives an introduction of the IMAT project, tools and IMAT follow-up research.
- Chapter 2 describes the evaluation and validation of IMAT at GGW De Peel.
- Chapter 3 contains an IMAT tools analysis and description of the new domain implementation.
- Chapter 4 gives an overview of factors influencing the use of the IMAT concept and tools in the RNLAF

- Chapter 5 presents the factor and requirement models that were developed and validated based upon the factor study as described in chapter 4.
- Chapter 6 presents conclusions and recommendations on the possible use of IMAT concepts and tools within the RNLAF organisation.

1.1 IMAT Project

IMAT is an acronym for Integrating Manuals and Training. The aim of the European IMAT[1] research project (de Hoog et al., 2002), conducted from 1998 until 2001, was the development of a set of tools supporting the effective and efficient re-use of the content of technical manuals for instructional purposes.

In many technical domains, the documentation of the equipment is the single and main source to create training material for maintenance engineers. However, technical manuals often are not directly useable as training material and need (extensive) revising and re-editing by training developers. Furthermore, maintenance training needs constant revising to keep the training accurate and up to date with the many changes in the system, their components, and the technical manuals.

In technical domains, training mostly consists of vocational training within companies. Instructors often are training developers as well, and usually have more (technical) domain expertise than didactic expertise. Experts in technical domains are scarce within their companies which often have to rely upon them for difficult maintenance tasks such as troubleshooting, training novices on the job, giving instruction, training development and keeping training up to date. This means a heavy burden on scarce expertise.

The goal of the IMAT project is to provide automated and structured support to make it possible to search and edit fragments of technical manuals into instructional material. The IMAT approach foresees the following steps:

- technical manuals are the input;
- the technical manuals are automatically fragmented;
- the fragments are indexed with suitable metadata;
- the indexed fragments are stored in a database;
- users are supported in searching the fragments they need and retrieving them from the database.

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[1] The IMAT project (ESPRIT 29715) was partly funded by the European Union. Partners in the project were: Intelligent Systems Laboratory, University of Amsterdam (NL), TNO Human Factors and TNO Physics and Electronics Laboratory (NL), Loria (F), Renault (F), AFPA (F), ETRA (E), Tecnopolis CSATA Novus Ortus (I), Royal Netherlands Airforce (NL), Eurisco (F).

It is then possible to export the instructional material to an authoring environment, for instance commercial off-the-shelf software such as Word, PowerPoint, Authorware, and such like.

1.2 IMAT Tools

The following tools were developed in the IMAT project:

- The Document Analysis Tool (AIDAS), which analyses, fragments and indexes technical manuals and other source material.
- The Authoring Environments Interface Tool, which allows retrieval of fragments from the database and transferral of selected fragments to the authoring environment. This tool also enables additional indexing and annotation of the fragments.
- The Organisational Memory Tool, which facilitates additional (manual) indexing and annotation of the fragments enabling organisational memory and learning on the use of instructional material in an organisation.
- The Ontology Development Tool which can be used to create ontologies in a structured way.
- The Instructional Scenarios Tool which supports the creation of frameworks for specific lessons for maintenance tasks. Within IMAT a lesson framework is made visible in a so-called Instructional Bag, a directory structure that reflects the lesson framework. The framework reflected in the Instructional Bag can be used as guidance for database queries and users can fill an Instructional Bag with the fragments required for different parts of the lesson. The Instructional Bag can then be exported to the Authoring Environments Interface Tool. Alternatively, users can directly copy and paste fragments to an Authoring Environment.
- The Database Facilities Tool enables IMAT users to manage the database where fragments of the source material are stored. This tool facilitates version management of fragments, necessary due to fragment updates and various lifestages of a fragment, e.g. the transformation of a fragment to an instructional fragment.
- IMAT Database: A Jasmine® database is used as central database in IMAT for the storage of fragments. This is an object-oriented relational database. Jasmine® was, amongst other factors, chosen for its ability to handle multimedia formats.

At the core of the IMAT tools lies a set of ontologies that were developed to describe fragments, both domain-specific and generic, and also from an instructional viewpoint. An ontology can be described as a structured list of concepts, keywords and format descriptions. Such ontology can be described, e.g. in a conceptual modelling language (CML) and be used by software tools to identify and describe fragments, such as audio or text, make distinctions between

different types of fragments such as titles and sections, and "recognise" specific content.

The next figure gives an overview of the general workflow in the IMAT tools.

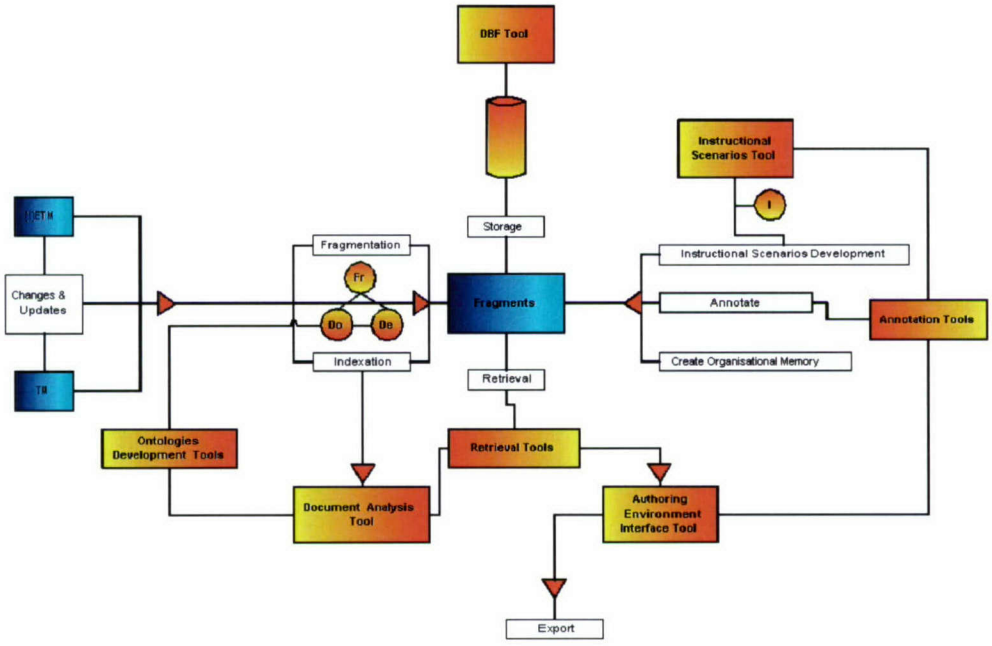

Figure 1.1: Overview of IMAT Workflow

The transparent boxes depict the processes in the IMAT workflow. The red arrows indicate the possible direction of this workflow in a training material development process with IMAT tools, from the delivery of source material to the export of fragments to an external-authoring environment. The orange boxes represent the IMAT tools, and the orange circles represent the fragmentation, description, domain and instructional ontologies. The blue boxes represent the source material in various life stages and forms, e.g. technical manuals, (interactive) electronic technical manuals and fragments.

Although it is possible to use the whole set of IMAT tools, it certainly is not necessary. One can for instance only use the fragmentation and search options provided with the AIDAS tool or only the Scenario Wizard of the Instructional Scenarios Tool as guidance to create maintenance lessons. A more detailed description of the IMAT tools will be given in chapter 3: Tools Analysis.

1.3 IMAT Follow-up Research

In the Netherlands TNO[2] and the Royal Netherlands Air Force (RNLAF) continued the IMAT research in IMAT follow-up research. The main goal of the IMAT follow-up project is to get insight in the usability of IMAT concepts and tools for technical training development within the RNLAF. A second goal is to determine how the IMAT approach can be exploited in the light of many other relevant training issues in the RNLAF's technical training domain. The RNLAF, for instance, decided to follow the ADL SCORM guidelines for the standardisation of e-learning content. Therefore, it is crucial to know whether or not the IMAT tools are (or can be) SCORM compliant. See for more information on this part of the research: Veerman, et al., (2002) and Janssen, et al., (2004). Furthermore, simulation-based training methods are used in the technical training domain. Here also technical manuals constitute the basis of the training material. The content of technical manuals changes and is updated regularly. This means that for simulation-based training it is essential to track these changes and update the training material in an easy way. Nowadays, it is almost impossible for the RNLAF to keep the training material of the simulations up to date with changes in the technical documentation. The IMAT tools could assist in this process. Another interesting phenomenon in the RNLAF is the implementation of Interactive Electronic Technical Manuals (IETMs) for aircraft maintenance.

Training and Education in the RNLAF
Within the RNLAF training and education play a crucial role in achieving and maintaining a high state of military operations. Technical training in the RNLAF often involves the transfer of crucial and critical knowledge and skills, for instance for air traffic control, aircraft maintenance and (tactical) fighter control. The use of advanced high-tech training solutions such as simulation is far more common than in the civil world. Another important characteristic of technical training is that the training material has to be updated frequently due to changes in the operational equipment and technical manuals. For reasons of personal and system safety it is essential to work with up to date source material, both in maintenance and technical training.

In the current situation for the training of maintenance engineers the RNLAF is confronted with the situation sketched in section 1.1: training material often is developed by the instructors themselves with the technical manuals as most important input. Instructors are domain experts with some experience in teaching, but not much background in instructional design and development of training material. In practice, developing training material takes up a lot of instructor time especially since there is a frequent update process, e.g. when personnel changes or the technical manuals are updated.

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2 TNO Defence, Security and Safety; Location The Hague and Soesterberg

Follow-up Research

During the European IMAT project, one of the RNLAF's airbases, GGW De Peel, co-operated in the project as a user-partner. Considering the close involvement of this user-partner in the tool development process (the tools were specified according to their needs), it would have been interesting to focus the follow-up research project on the integration of the tools at the GWW De Peel airbase. However, due to reorganisations GGW De Peel could not continue to use the IMAT tools and be part of the follow-up research project. In chapter 2 we briefly describe these developments and summarise the main conclusions of the last evaluation at GGW De Peel.

To address the issues that remained open for the RNLAF, the IMAT follow-up project was set up with the next research questions in mind:

a) How usable are the IMAT tools for new domains?
b) What are the possibilities for using IMAT knowledge and tools elsewhere within the RNLAF? Which other training issues are relevant in this context?
c) How do the IMAT meta-data relate to the ADL SCORM standard that the RNLAF has decided to adopt?
d) How do the IMAT knowledge and tools relate to the SCO-generator for the RNLAF?

The first report, IMAT Follow-up Research Part I, addresses question A and B. The second report, IMAT Follow-up Research Part II, elaborates on question B and answers question C and question D.

To answer question A, we started with a summary of the most important lessons learned on the usability of the IMAT tools at GGW De Peel in the European IMAT Project (See: Chapter 2). Also, we tried to implement a new domain in the IMAT tools (See: Chapter 3). To answer question B, we investigated educational, technology and organisational factors influencing the possible use of IMAT concepts and tools in the RNLAF (See: Chapter 4) and developed factor and requirement models to study the way these factors interact and influence the use of IMAT in the RNLAF (See: Chapter 5). The models were validated and elaborated by expert reviews and interviewing key (RNLAF and TNO) experts. The conclusions and recommendations for the future use of the IMAT concept and tools within the RNLAF are presented based upon the work as described in reports I and II on the IMAT follow-up research in Chapter 6.

2. Evaluation and Validation of IMAT at GGW de Peel

Section 2.1 describes organisational developments at GGW De Peel. In section 2.2 we summarise the most important results of the evaluations executed within the European IMAT project at GGW De Peel.

2.1 Organisational developments at GGW De Peel in 2002

GGW De Peel has been directly involved in the European IMAT Project (Integrating Manuals and Training, Esprit Project number 29175) in the role of user. This has meant that instructors from GGW De Peel have collaborated in the definition of user needs for the methods and tools to be developed, as well as in the evaluation of three IMAT prototypes.

2.1.1 HAWK issues

In the first part of the European IMAT project the domain that was used was the training of maintenance engineers for the Flycatcher (prototypes 0 and 1). Since the RNLAF decided not to continue the Flycatcher maintenance training, the HAWK domain was used in the second half of the project (prototype 2).

For the IMAT follow-up project the following activities were originally foreseen at GGW De Peel in 2002:

- introduce new HAWK material into the prototype tools when it becomes electronically available (during the European project only three manuals were available electronically);
- develop lesson material for the HAWK course using the prototype tools (including the instructional scenarios tool);
- further evaluation and validation of the IMAT concepts and tools for GGW De Peel specifically, and for the RNLAF in general.

In December 2001 the final versions of the IMAT prototype tools, with improvements implemented after prototype version 2, have been installed at GGW De Peel. There were still some technical problems with the HAWK electronic material. In the first few months of 2002 TNO and GGW De Peel collaborated with the University of Amsterdam (responsible for the implementation of the AIDAS tools) to solve these problems. The expectation was that the other HAWK manuals would soon become electronically available, but that did not happen. We could, therefore, not introduce new HAWK material in the IMAT prototype tools.

Around the same time it became clear that there would be no maintenance engineer courses for the HAWK in 2002. For the instructors at GGW De Peel the development of lesson material for the HAWK course was, therefore, no longer a

priority. By September 2002, it became apparent that the RNLAF would not continue training for new maintenance engineers for the HAWK as the system would not be used much longer. In the future, the RNLAF plans to purchase the PATRIOT as new air defence system. The training of maintenance engineers for the PATRIOT will probably be outsourced.

2.1.2 Conclusions

The source material for the HAWK was problematic because of the low quality of the material (not originally electronic, but scanned in) and the layout of the documents was inconsistent. Since the RNLAF has decided to stop training HAWK maintenance engineers, it does not seem sensible to dedicate more time and effort to this domain. Further evaluation and validation of the IMAT concepts and tools was not possible at GGW De Peel, because no lesson material for the HAWK had been made. We therefore decided to try to implement a (realistic but not too big) domain ourselves in order to get a better view on how usable the IMAT tools would be for new domains (see chapter 3).

2.2 Main results of the evaluations within the IMAT project

In this section we summarise the most important results of the evaluations executed within the European IMAT project. For a more elaborate report see: Verstegen, Veldhuis, Staalstra, and Hendriks, (2001) and Verstegen et al. (2001).

2.2.1 Evaluation of the IMAT concepts and tools: general conclusions

The evaluation of the IMAT concepts and prototype tools was an important part of the European IMAT project. Evaluations took place at the three user sites involved in the project:

- in the Netherlands at the RNLAF, GGW De Peel. Domain: training of Flycatcher/Hawk maintenance personnel;
- in France at AFPA. Domain: lower vocational training for mechanics for the Renault CLIO); and
- in Spain at ETRA. Domain: training for maintenance and repair of traffic control systems.

Three domains were implemented in the IMAT tools and the tools were used to create lesson material. Further evaluation data consists of answers to questionnaires and semi-structured interviews (Verstegen et al., 2001).

At the end of the project IMAT users saw many potential benefits of using the IMAT concepts and tools:

- it reduced the time spent on making lesson material and therefore the costs; and it supported,

- the standardisation of lesson material;
- the reuse of source and lesson material;
- knowledge sharing between instructors (and other staff); and
- knowledge management.

The most important remaining problems concerned the analysis and indexing of source material. Most of these problems seemed to be of technical nature.
The next most pressing problem was the updating problem: at this moment the database has to be refilled when there is an update of the technical manuals. This means that all instructor changes (revisions in fragments, additional fragments, additional indexes, annotations etc.) are lost and therefore severely hamper the use of the facilities to revise and add fragments, add annotations and add/change indexes.

The user evaluation confirmed the choice made earlier in the IMAT project to keep the different tools independent and separate so that users could choose which tool they wanted to use and when. All tools are connected through the database.

2.2.2 More specific results from RNLAF users

The RNLAF users are positive about the Instructional Scenarios Tool. They could follow the lines of reasoning in scenario construction without problems. The resulting list of Instructional Activities is similar to the standard lesson structure as they were taught during their instructor training (only they use different definitions, i.e. introduction; presentation; feedback). Making a lesson structure (i.e. an Instructional Bag) without the Instructional Scenarios Tool was considered to be less easy.

The RNLAF users found inserting fragments into an existing Instructional Bag an easy way to make a lesson, but it would have been easier if drag and drop-functions were available. We discovered that it was not possible to insert cut-out parts of pictures into the bag[3]. Exporting bags appeared easy: the tool constructs a structure in which pictures, texts, video, etc. can be saved. Cutting and pasting fragments directly from the Authoring tool to PowerPoint also worked without problems. According to the instructors using Instructional Bags was more useful than constructing lesson materials directly with copy and paste to the authoring tool. When using the tool in practice, they would expect to make training material using Instructional Bags in most cases.

Regarding the annotation facilities, RNLAF users remarked that the number of choices was rather large. Most of the choices apply to (parts of) lessons and not to individual fragments, for example: misunderstandings and recovery strategies that can only be filled in during training.

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[3] It is possible to cut out parts and copy them directly to an authoring environment, or to save the picture to a file and use other software to work on it.

The instructors were very positive about the possibility to save annotations with (parts of) Instructional Bags. They did not expect to use annotations with individual fragments. A main problem that occurs when the database is updated is that the annotations with fragments could get lost. It is not clear whether Instructional Bags plus the related annotations might also get lost. Ideally, there should be a way of keeping track where fragments are used, so users are warned when a fragment is updated.

2.2.3 Conclusions

Using the Instructional Scenarios Tool and the annotation facilities has several advantages:

- Lesson material will be more consistent & lesson material can be reused;
- Multiple instructors can easily use the same lesson material, instead of making their own lesson material on overhead sheets as was done before. As a result, instruction differed strongly between instructors, and there was little (or no) awareness of what learning goals were being addressed. Using the same scenario and material will ensure consistent lessons. Using the annotation facilities will make it possible to share and store experiences and comments.
- Saving the selected fragments in the structure of the Instructional Bag will make it easier to co-operate with other instructors during the creation of lesson material.
- Using Instructional Bags will be especially useful when the lesson material is implemented by other people (e.g. in Authorware by Multimedia developers) or when implementation is outsourced.
- Using Instructional Bags will make it easier to revise training material after updates, especially when instructors use an authoring tool where fragments are imported from file on the fly. In this case out-of-date fragments could be simply replaced in the Instructional Bag and repeat creation of the lesson material would not be necessary.

The RNLAF users did not find the facilities to add/change indexes of fragments, easy to use. They also expected that it would be used less frequently when the amount of material in the database was very large. They agreed that it is necessary to be able at least to change indexes that are obviously wrong. But in this case, the updating problem should be solved as well: it would not be sensible to improve the indexes of fragments in the database, if these changes all get lost when the database has to be refilled after a manual update. The same problems occur when fragments are revised or new fragments are added to the database. Use of the instructional indexes was not foreseen at GGW De Peel.

3. IMAT Analysis

Section 3.1 starts with a description of the IMAT tools for a better understanding of the various tools and the workflow in the IMAT process. In section 3.2, the results of the tools analysis, based upon the work for a new domain implementation, are presented.

3.1 Overview of IMAT Tools

In this section a more detailed description of the IMAT tools is given. The following tools are described: the document analysis tool (AIDAS), the authoring environment interface tool, the instructional scenarios tool, the organisational memory tool, the database facilities tool and some tools which are integrated within one of these tools, such as fragment retrieval tools and the ontology development support tool.

3.1.1 AIDAS

AIDAS is an acronym for the Amsterdam Intelligent Document Analysis System and is used in IMAT as name for the (automatic) documentation analysis tool. Its main purpose is to break up the content of technical manuals into smaller text and image fragments. These are then provided with an index, which describe fragments from various viewpoints, and are necessary for proper fragment identification. Finally the AIDAS tool enables the export of fragments to the Jasmine® database, which is used in IMAT as central database.

3.1.1.1 Ontologies

In IMAT, the proposed solution on problems with information retrieval and indexing is based upon ontology indexing. IMAT uses different ontologies, representing various point of views to create fragments. These ontologies play a key role in the IMAT solution. By defining the ontologies, IMAT tools are able to fragment, retrieve and describe content. The ontologies were developed with a close look at the work done in similar projects on ADL SCORM, LOM and Ariadne (www.adl.org) for the standardisation of metadata for electronic content.

In IMAT a distinction is made between generic and domain-specific ontologies. The following ontologies were developed in the IMAT project (Anjewierden & Kabel, 2001):

- Fragment ontology: general and syntactic viewpoint;
- Description ontology: semantic viewpoint;
- Instructional ontology: instructional viewpoint;
- Domain ontology: domain specific viewpoint.

The various ontologies enable the indexing of fragments from several points of views. The *fragment ontology* captures fragment aspects from a general and syntactical viewpoint. This ontology enables the description of fragments in terms of this fragment *"is a video"*, or *"the size of this text fragment is"*.

The *description ontology* describes the fragment type and gives a semantic viewpoint on a fragment. By the use of this ontology either the content of a fragment is (briefly) described, or the location or structure of a fragment, such as location *"TM-1234-89a"*.

The *instructional (roles) ontology* represents the instructional viewpoint and enables the description of possible instructional roles for a fragment. A fragment, which is indexed as *"video"* could become in an instructional context an *"example"* or part of an *"exercise"*. The components by which this ontology gives an instructional description of fragments are learning goal, knowledge type, instructional strategy, instructional activity, instructor and learning actions, and material use. Parts of this ontology are used to add instructional metadata to fragments (e.g. *"knowledge type"* and *"material use"*) and other parts of this ontology can be used for the development of instructional bags (see for more information: section 3.1.4). The instructional ontology is designed with a focus on maintenance training, and contains a specific (maintenance) part and a generic (instructional) part. This ontology can be re-used in other training domains requiring a focus on (complex) cognitive skills for system maintenance. However, the generic part of the instructional ontology, can be re-used in any other training domain.

The *domain ontology* gives a conceptual description of a domain, such as the description of a system or domain. The domain ontology can consist of a generic and specific part. Within IMAT the generic part of the domain ontology is called the system ontology. The system ontology describes systems in terms of concepts applicable to various domains, such as unit and component. The specific part of the domain ontology deals with specific concepts used in a certain domain, and varies per domain. The domain ontology is the only ontology that is (for the largest part) not generic and will have to be redeveloped for a new technical domain implementation. For the RNLAF it is important to know how much time and effort it will take to create new domain ontologies and how the ontology development tool can assist this process.

3.1.1.2 Document Analysis

The document analysis process distinguishes the following four phases (Anjewierden, Wielinga & Kabel, 2001):

- Source Material Interpretation:
  AIDAS enables the automatic interpretation of Portable Document Format (PDF) and Extensible Mark-up Language (XML) documents.
- Discovery of the logical document structure:
  Through incremental analysis the layout structure (sections, tables, images, etc.) of a document is analysed to discover the logical structure.
- Indexing and fragmentation of the logical document structure:
  Ontologies are used in this stage to index text and image fragments created by the document analysis process. The ontology descriptions are represented as a set of concepts in a CML format.
- Storage of the document fragments in a multimedia database:
  Finally fragments (and their indexes) are stored in the Jasmine® multi-media database.

The next figure gives a graphical overview of the AIDAS main window.

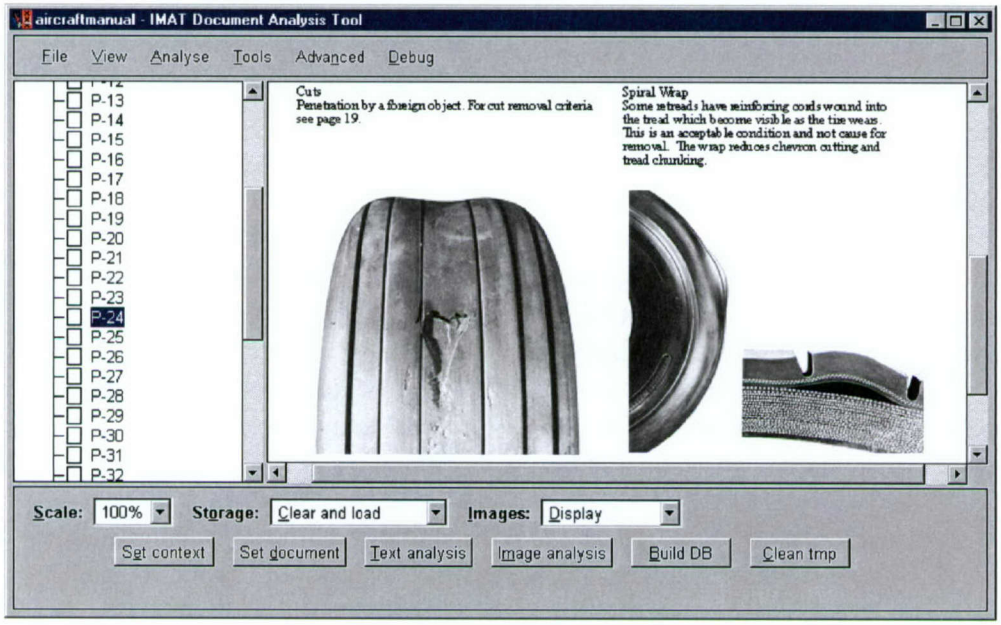

Figure 3.1: AIDAS tool: Main window

Although it could be argued that the document analysis process does not necessarily need a user-interface (it is an automatic process), user evaluations in the IMAT project clearly showed that an interface should be provided enabling human inspection during the document analysis process. Therefore the AIDAS tool provides presentation views of:

- HTML output for the conversion of PDF files to HTML,
- Analysed text, and

- Analysed images.

The images are converted to SVG format to enable image analysis. Through the use of various colours an AIDAS user can see which parts of the document (text and images) are analysed in what way. Examples and details on this matter will be given in section 2.2.3: Working with AIDAS.

Two other tools (or functionalities) are integrated in AIDAS. These tools are the Fragment Search Tool and the Ontology Development Support Tool. The latter tool will be further described in section 2.2.2: Ontology Development.

The fragment search tool enables search and inspection of text fragments prior to storage in the central database. It is not possible to export text fragments retrieved with this tool to other tools or environments. For this purpose, the Authoring Environments Interface Tool is designed in IMAT (see next section).

3.1.2 Authoring Environments Interface Tool

The general purpose of the Authoring Environments Interface Tool is to enable the delivery of fragments stored in the multimedia database to an authoring environment of choice.

Within the IMAT project it was decided to leave the authoring environment to the free choice of user organisations. They can then choose the authoring tools they prefer to use in the development and delivery process of training varying from Word or PowerPoint, to tools such as Toolbook and Authorware[4] or a Learning Content Management System (LCMS).[5] At the start of the IMAT project it was strongly felt that organisations should use the authoring tools they were using already in their organisation or that they would prefer to use. "Prescribing" authoring tools to the IMAT user organisations/partners would limit their organisational and instructional design choices and would probably not have been accepted by the user partners in the IMAT project due to the need (and risks) to migrate to a new and unfamiliar authoring environment.

In the next sections the main features of the authoring environments interface tool are described (section 3.1.2.1), fragment retrieval (section 3.1.2.2) and fragment mark-up provided by the indexing support tool (3.1.2.3).

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4 Toolbook and Authorware are two examples of common CBT or WBT authoring tools.

5 An LCMS combines LMS functionalities with an authoring environment and a content management system.

3.1.2.1 Main features

The Authoring Environments Interface Tool enables the delivery of fragments to an external authoring environment in two ways. They are:

- Copy, cut and paste fragments (extracted from the database) in the Windows clipboard or save them directly to files.
- Through the use of instructional bags: this provides a user with a more advanced way of creating training material. See also section 2.1.4: Instructional Scenarios Tool.

The next figure gives an overview of the main window of the Authoring Environments Interface Tool. Functionality provided by this window includes:

- Connection with the IMAT database,
- Fragment Management: this includes fragment content management, search, retrieval and display of fragments, and
- Instructional Bag Functionalities: this includes a link with the Instructional Scenarios Wizard in the Instructional Scenarios Tool, and also to import an existing instructional bag, or create one by hand directly in this window. An instructional bag can be used as basic structure to query the database for fragments.

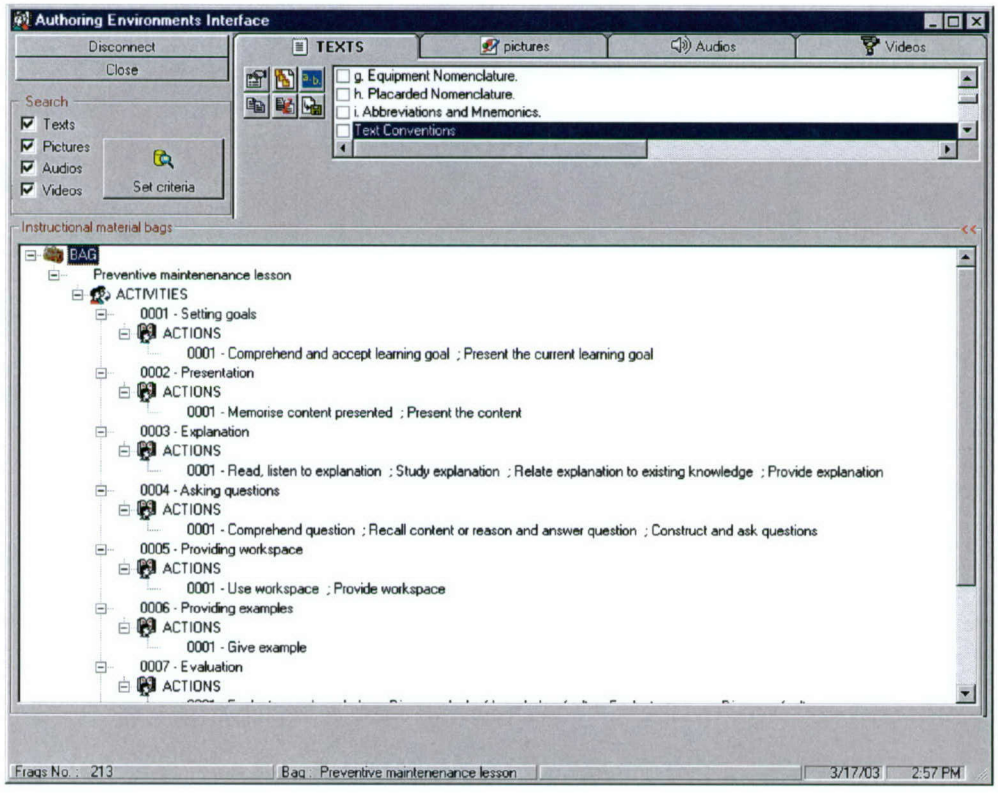

Figure 3.2: Authoring Environments Interface Tool: Main Window Overview

The Authoring Environment Interface Tool Window is divided in two parts:

- Via the [set criteria] button a user can search and retrieve fragments (for example: text or picture fragments), which are presented in top frame of the window, a user can also (by selecting one of the other buttons) create fragment mark-up and annotations (see for more information on this matter the next sections),
- In the largest frame of the window a user can import an instructional bag or create one by hand directly in this frame. By means of a direct link from this window it is also possible to create an instructional bag guided by the Instructional Scenarios Wizard. When an instructional bag is created, it is possible through the Authoring Environments Tool to query the database, and insert fragments directly into the instructional bag. An instructional bag also enables the (temporary) storage of multiple fragments during a fragment search.

See for more information on the creation of instructional bags and the Instructional Scenario Wizard section 3.1.3: the Instructional Scenarios Tool.

3.1.2.2 Fragment retrieval

The next figure gives an overview of one of the fragment retrieval options provided in the IMAT tools. This window displays the Fragment Retrieval Window connected to the Authoring Environments Tool.

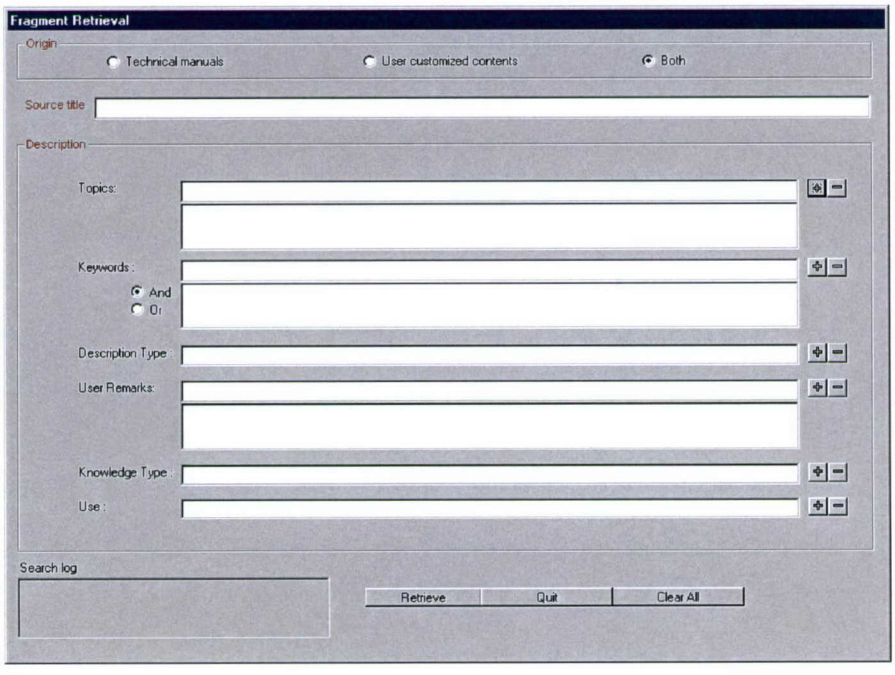

Figure 3.3: Fragment Search and Retrieval

It is possible to retrieve fragments stored in the database from the original technical manuals or fragments which have been altered and annotated for instructional

purposes, such as instructional fragments or instructional bags. The fragment retrieval tool enables a search in the IMAT database through various options such as topic search, keyword search, or the search of fragments concerning a certain knowledge type. The predefined concepts in the various search options are based upon the developed ontologies in IMAT. In the grey frame at the lower left side of the fragment retrieval window a search log presents the number of fragments found in the database given certain search criteria.

3.1.2.3 Indexing support tool: fragment mark-up

Fragment mark-up can be seen as a first step to connect a fragment, from an instructional perspective, to a suitable concept, such as topic, keyword, knowledge type or fragment use. The indexing support tool supports fragment mark-up, and this functionality is also provided in the Database Facilities Tool. Fragment mark-up can be done both at the level of a single fragment or multiple fragments at once. The next figure gives an overview of the Fragment Mark-up Window.

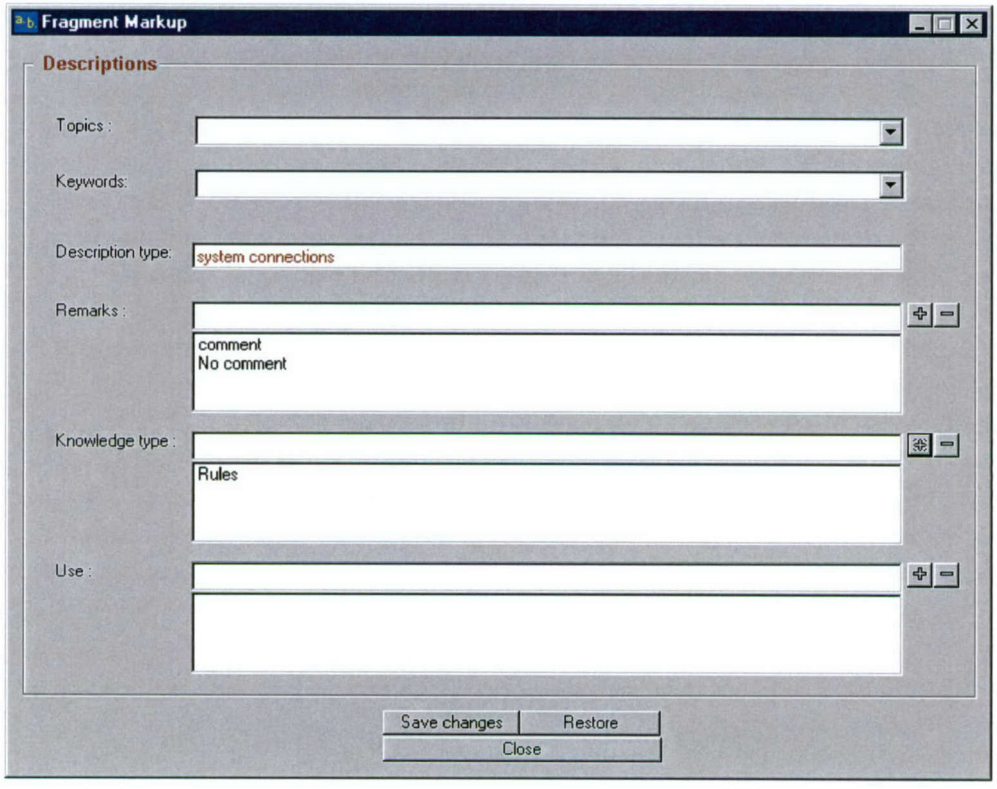

Figure 3.4: Fragment Indexing Tool

The Fragment Mark-up Window displays various categories assisting a user with predefined concepts related to the domain (derived from the domain ontology), and possible instructional use of a fragment. The concepts, such as knowledge type, are presented when a user clicks on a [+] button, after which a selection can be made, and are derived from the instructional ontology. By the use and selection of predefined concepts, fragment search and retrieval is enhanced. Not only because

the same concepts are used between different users, also because typing mistakes are prevented.

3.1.3 Organisational Memory Tool

The general purpose of the organisational memory tool is to assist users in the process of creating annotations for fragments, and to facilitate organisational memory and learning on the use of instructional material in an organisation. In essence, the organisational memory tool facilitates knowledge sharing of fragments between different users. Annotations are an aspect of knowledge sharing and give users of a fragment the possibility to add own comments, ideas, opinions, expertise and experience to information available in the IMAT database. A user of a fragment could be anyone with access to the IMAT database. A user could have for instance the role of creator, designer or developer of a fragment, instructor, or database manager. Even trainees or end-users of fragments could be given rights to access the database to create annotations.

Annotations can provide rich sets of information on the use of a piece of information, from various perspectives: through users with different roles, during different lifestages of a fragment, such as prior to instructional use (design and development phase), during instructional use (training phase) or afterwards (evaluation phase). Annotations can be very useful for an organisation since they can provide a structured format to share knowledge and experience on the use of instructional material (in the case of IMAT) and create organisational memory and knowledge, even among parties not working on the same physical location.

One can think of making annotations for the purpose of version management, tracing down decisions, communication with others, and providing additional information on a fragment. Other reasons for using annotations could be authorisation and release management (when should a certain piece of information be published, and for whom). Annotations can also serve as a memory, e.g. as reminder that the fragment contains a mistake and should be updated with a new release of the technical manuals.

In IMAT it is possible to create annotations for:

- Fragments, stored in the database;
- Instructional bags as a whole;
- Didactic actions within instructional bags;
- Media fragments linked to the didactic actions in an instructional bag.

The next figure gives an overview of the Annotations Window of the Organisational Memory Tool.

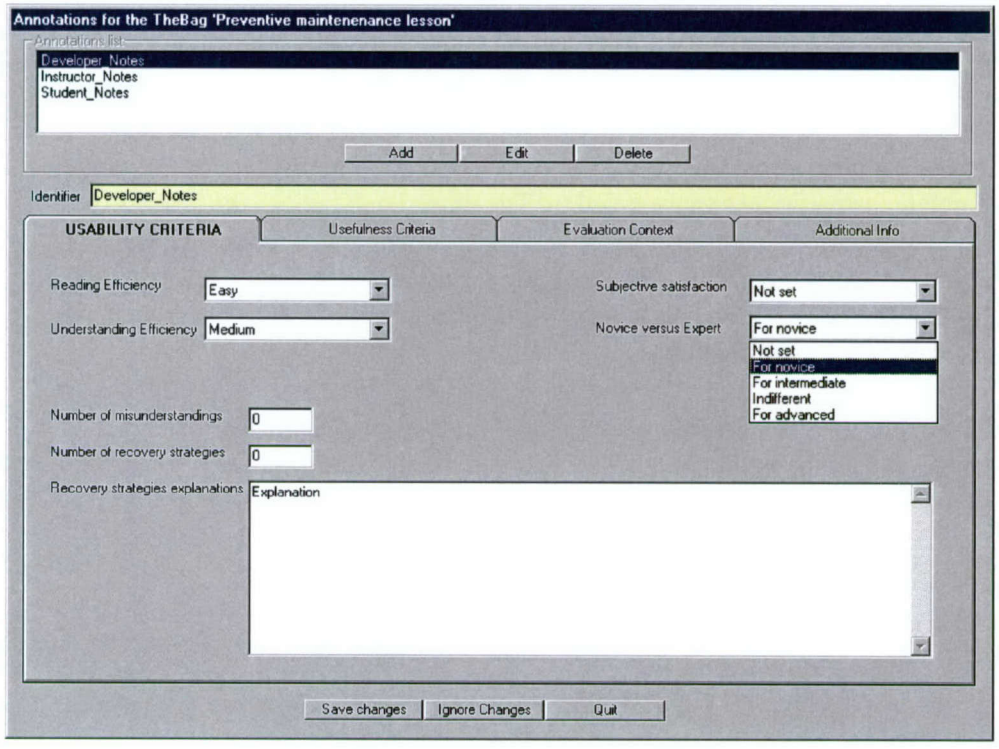

Figure 3.5: Organisational Memory Tool: The Annotations Window

In the IMAT annotations system four categories are distinguished:

- Usability: this category contains items to describe a fragment, such as reading efficiency, understanding efficiency, misunderstanding and recovery strategies, subjective satisfaction and target group.
- Usefulness: this category contains items to describe a fragment, such as relevance, internal and external consistency, tractability and course appropriateness.
- Evaluation context: this category is important to fill in as a reminder for the creator of an annotation and others reading the annotation, because it provides information such as who made the annotation, when and why.
- Additional Information: this category provides the user (amongst others.) with a free text option to fill in any other information on a fragment that might be relevant.

Each of these four categories is presented on a tab page in the Annotation Window, and drop down boxes with pre-set options or free text options are provided to annotate a fragment.

3.1.4 Instructional Scenarios Tool

The Instructional Scenarios Tool supports a user with the creation of a standard structure for a specific lesson (skeletal lesson). In the Instructional Scenarios Tool a user is guided and assisted by an Instructional Scenarios Wizard.

The assistance provided by the instructional scenarios wizard to a user can be compared to the way a filter works. After the selection of a learning goal, the first step in the creation of an instructional bag, the wizard filters options based upon the first selection and prior to the next step in the process presents only those options making sense. This process is repeated until all the steps necessary for a complete instructional bag are filled in. The wizard only guides the process by eliminating false or contradictory options but will not interfere with choices made by an instructional designer. However, the set-up is that of a wizard, meaning that it guides the steps of a user in a directive manner and prevents a user from making mistakes as much as possible.

The next figure gives an example of one of the steps in the wizard, where a user can select a predefined concept. The figure gives an overview of the first step of the instructional scenario wizard: the learning goal choice.

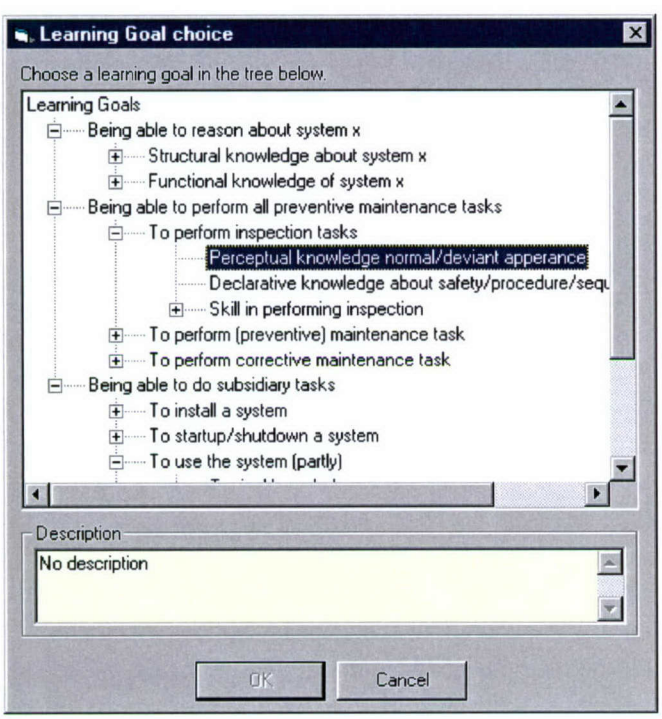

Figure 3.6: Learning Goal Choice

The concepts presented in the various steps of the instructional scenarios wizard are derived from the instructional ontology. The next figure gives an overview of the instructional scenarios wizard with a filled in scenario for an instructional bag.

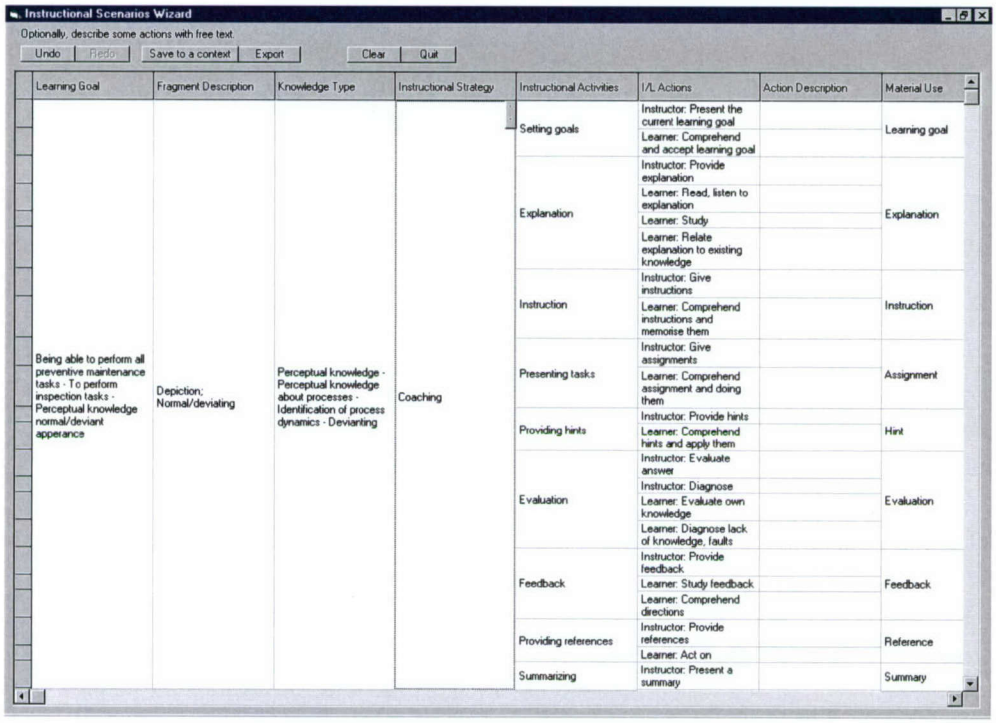

Figure 3.7: Instructional Scenarios Tool: Overview of a filled in scenario constructed with the help of the Instructional Scenarios Wizard.

The next steps are defined and guided by the instructional wizard in the process of creating an instructional bag (Barnard, Desmoulins & Grandbastien, 2002). They are:

- Set a learning goal: As first step, a user can select a learning goal from a list of learning goals designed for technical training.
- Fragment Description: The Wizard will then automatically select a fitting fragment description.
- Determine the knowledge type: As the next step, a user has to select the knowledge type a student needs to obtain, such as "performing skills" or "procedural knowledge". A selection can be made from a list of knowledge type concepts derived from the instructional ontology.
- Choose an instructional strategy: The next user step is to select an instructional strategy that is suited for the intended lesson, students and classroom organisation. Again, selecting one of the options presented by the wizard has to be done. Note that the wizard acts as a filter and will present only those instructional strategies relevant and not contradicting previous choices.
- Determine a set of instructional activities: the wizard will then automatically select a set of instructional activities. The concepts presented are derived from the user's choice for a specific instructional strategy.
- Instructor and learner actions: The wizard will also present a sequential list of instructor and learner actions that are connected to the instructional activities.
- Create an action description: A user can (optionally) describe an action further.

- Material Use: This is finally presented by the Wizard as a further refinement of instructor and learner actions, and describes the type of material to be used in a certain lesson.

It is possible to use the Instructional Scenarios Tool as a stand-alone tool or in conjunction with the IMAT database. The latter is possible through the export of instructional bags to the Authoring Environment Tool, where an instructional bag can be used to query the database for fragments.

3.1.5 IMAT Data-handling

This section will describe aspects related to the IMAT Database and the adjacent Database Facilities Tool to give a complete description of the IMAT concept, since they both fulfil a central role in using the IMAT tools.

3.1.5.1 Jasmine®: the multimedia database

In the IMAT project several commercial off the shelf software products were used, among which, the Jasmine® database. This is an object-oriented relational database used to store fragments in various stages of their lifecycle. Jasmine® was, amongst other factors, chosen for its ability to handle multimedia formats. The IMAT database is the central unit where fragments are stored, retrieved and managed in their various states during the IMAT process of creating fragments, instructional fragments and instructional bags.

3.1.5.2 The Database Facilities Tool

To be able to manage the fragments in various stages and forms in the database, i.e. version management and perform other management tasks, such as loading or clearing a context and editing domain ontologies the Database Facilities Tool has been developed.

The Database Facilities Tool supports:

- Ontology modification: the database facilities tool enables the modification of an existing ontology stored in the database.
- Fragment mark-up. It is possible to create fragment mark-up through the same user interface as provided in the Authoring Environment Tool, see figure 3.3.
- Textual Fragment Upgrade: It is also possible to perform a textual upgrade on a text fragment in any state of the lifecycle of the fragment (draft, original or instructional material) to correct mistakes in a fragment. Since typing errors are one of the more common mistakes in technical manuals, this option can be very useful, especially in domains where the update cycle of technical manuals takes considerable time.
- Version management: The database facilities tool enables version management of fragments derived from the technical manual and "edited" instructional fragments.

- Annotations: in the database facilities tool annotations can be created, for:
  - Fragments, derived from the technical manual, and
  - Updated, changed or newly created fragments. The user interface provided for the creation of annotations in the Database Facilities Tool, is the same as in the Authoring Environment Tool, see figure 4.

As described in chapter 2 on the lessons learned in the European IMAT project and GGW De Peel an important remaining problem concerns the automatic support of changes and updates in technical domains by IMAT. However, in domains without large amounts of updates per "update moment" it is possible (and manageable) with the version management facilities provided by the database facilities tool, to search and retrieve instructional fragments and update them manually if necessary. This type of change and update management will prevent the (manually added) instructional indexes from getting lost, as would be the case after an automatic rebuild or refill of the Jasmine® database.

3.2 Tools Analysis

The next sections describe the results from the study concerning a new domain implementation and focuses on the usability of the current version of IMAT tools.

3.2.1 Purpose of a new domain implementation

Considering that the IMAT tools were designed and developed during the European IMAT project, it is important to understand that the goal of this project was not to construct a set of fully developed commercial tools, but rather a set of prototypes sufficiently developed and evaluated to start the construction of commercially exploitable tools. However, as part of the IMAT follow-up research it was decided to study whether the Pfinal set of tools would or would not be directly usable.

During the first part of the European IMAT project the Flycatcher domain was used as the example domain for testing the tools. When it became clear that the RNLAF would cease to provide training for Flycatcher maintenance personnel, this domain was abandoned and the HAWK domain was implemented. Many technical problems occurred during the implementation of the Hawk domain in the IMAT prototype tools due to a combination of:

- technical problems and lacking stability of the prototype tools that were still under development;
- no emphasis on user friendliness and exhaustive manuals for these tools under development;
- quality of the source material: the electronic HAWK manuals were scanned from the paper version; problems arose because the text was not clear (letters

incomplete or too close together), irregular position of pictures (skewed on the page), etc.

It was not clear which of these factors had caused the problems and in how far the problems had been solved in the final prototypes that were delivered after the last evaluation rounds. Therefore, we decided, as part of the IMAT follow-up project, to try to implement a new domain. More specifically, we wanted to investigate the effort required in adding a new domain to the IMAT tools. We aimed to gain insight in the usability of the current version of the tools, and how feasible it is for non-IMAT experts to add a new domain to the tools. We had the following questions in mind:

- How difficult is it to create a (new) domain ontology?
- How difficult is it to implement the domain ontology in the tools?
- How difficult is it to tune the AIDAS tools to new source material?
- How difficult is it to get the text and image analysis working in a new domain?
- How stable are the analyses, do they render the same results over several trials? on different computers?
- Do the analyses work on all parts of the text and images?
- Do the fragments get into the database?
- Can we easily retrieve the fragments again from the database?

3.2.2 Method

For the purpose of this study, a new domain has been added to the IMAT tools. It was anticipated that help might be needed from other IMAT partners[6] that had been responsible for the development of the tools. In that case, a clearer view on the amount of help and related costs for a new domain implementation could be estimated.

The findings and experiences with regard to the research questions are described according to the steps involved:

- Selecting a domain (see section 3.2.3);
- Developing the domain ontology (see section 3.2.4)
- Adding new domain files to the IMAT directory (see section 3.2.5)
- Starting the text and image analysis (see section 3.2.6)
- Retrieving fragments (see section 3.2.7)
- Exporting fragments (see section 3.2.8)

3.2.3 Selecting a new domain

Since the questions were mainly of technical nature and did not address specific RNLAF issues, it was decided to try implementing a new domain without the necessity of using RNLAF domain expertise. For this reason, and to make the

6 Especially, ISLA at the University of Amsterdam.

results comprehensible for non-domain experts, we searched for a technical maintenance domain that was limited in complexity. This initiated a search for source material, an electronic technical manual, compliant with the following demands:

- Non-confidential;
- Available for free;
- PDF or XML format;
- Containing both text and pictures;
- Good quality;
- Realistic size, but not too big.

A search with Google on the Internet, according to these criteria resulted in the selection of a technical manual, in PDF format. The manual was publicly available and downloaded from www.goodyearaviation.com/tirecare.html. The selected document, 'Aircraft Tire Care and Maintenance' concerns the aircraft tire maintenance domain. It is a technical maintenance domain that is not too complex (non-experts will fairly easily become familiar with the domain).

What is interesting to note, is the fact that this manual is written in a task-oriented manner, which is very different from the more system-oriented manuals used in the European IMAT project. For this reason, the following additional questions came to mind:

- Do the generic ontologies (developed during the European IMAT project) "match" sufficiently with this new domain?
- Should the (to be developed) domain ontology contain a system and a task-oriented part?
- Could the (generic) instructional ontology be used to index the task-oriented parts of the technical manual?

3.2.4 Developing the domain ontology

The second step was to create the domain ontology for the selected domain. The ontology should describe the domain in a systematic manner in order to support the indexing of the technical manual into meaningful fragments and to index them on topic. The system ontology describes, in essence, systematically the compounds of the system.

The development of a domain specific ontology is assisted by the IMAT tools in the following three ways:

1. A new ontology can be created automatically from a structured part lists of the equipment, e.g. from a table of contents from technical manuals, followed by manual fine-tuning.
2. A new ontology can be created manually from scratch using the ontology development support tool
3. Existing ontologies, stored in the database, can be modified using the ontology development support tool or the database facilities tool.

In the study, we reused an existing ontology to create a new one for the selected PDF manual on aircraft tires maintenance the aircraft tire domain. We followed the following steps in creating the new domain ontology:

First, the IMAT generic system ontology was analysed. This has been done by analysing the specification of the generic ontology in the CML file and creating a paper-based graphical representation of the aircraft tires domain to visualise the relevant 'is-a' and 'part-of' relations between system compounds, subsystems, and system locations. This representation provided a systematical framework of all kind of relations that a system ontology could contain.

Next, the structure of the specific domain ontology developed in the IMAT project for the Hawk domain was analysed to see how compounds of the Hawk system were linked to the compounds of the generic ontology. This provided a useful example of a domain ontology and how it is mapped on the generic system ontology, the compounds and several identity relations. The graphical representations of the generic ontology and the Hawk ontology served as reference for building the new domain ontology and implementing the relations.

Then, a paper-based graphical representation of the new domain ontology ('the aircraft tire ontology') was created according to systematic descriptions and graphical representations of the system in the manual. Often, the domain ontology can be generated on basis of an index, a table of contents, or a tree diagram of a system overview in the manual. These general indexes serve as good representations of a compound system or at least as good starting point. However, in the aircraft tire maintenance domain this was only partly true. The manual is written from a task-oriented perspective and the table of contents reflects the maintenance tasks involved rather than units that the system is compounded of. For example, one chapter describes the inspection, repair & storage tasks and another chapter the preventive maintenance tasks for various system parts.

Considering that the generic IMAT domain ontology describes the system compounds rather then the maintenance tasks involved, the domain ontology could not be generated on basis of the table of contents. In the end, other parts of the document, like lists of compounds and graphical overviews of system parts (such

as depicted in the figure below) served as a source of input for creating the ontology.

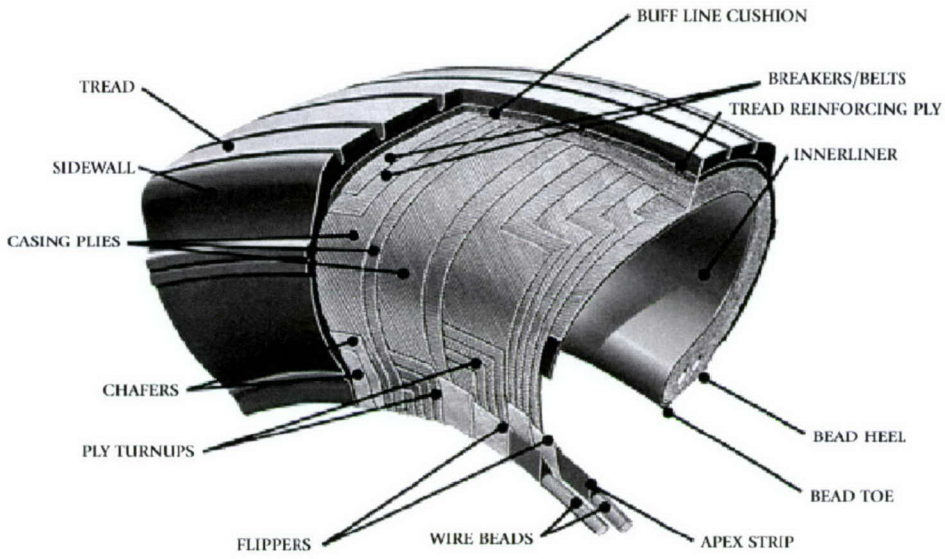

Figure 3.8: Aircraft tire parts overview from the technical manual

A problem came up when we wanted to implement some location relations: For example, the aircraft tire manual describes areas and (sub)systems that are located in such an area (e.g. bead area). However, the Hawk ontology (which served as an example of how to implement the relations) does not contain any location relations. Additionally, the IMAT manuals also do not address these more complex relations. In the end, we decided not to implement the location relations in the final ontology.

The resulting graphical presentation of the ontology with the relevant 'is-a' and 'part-of' relations has been enhanced with synonyms and abbreviations where relevant. The figure below shows a part of the ontology in an unfinished state (the blocked boxes represent the generic system ontology).

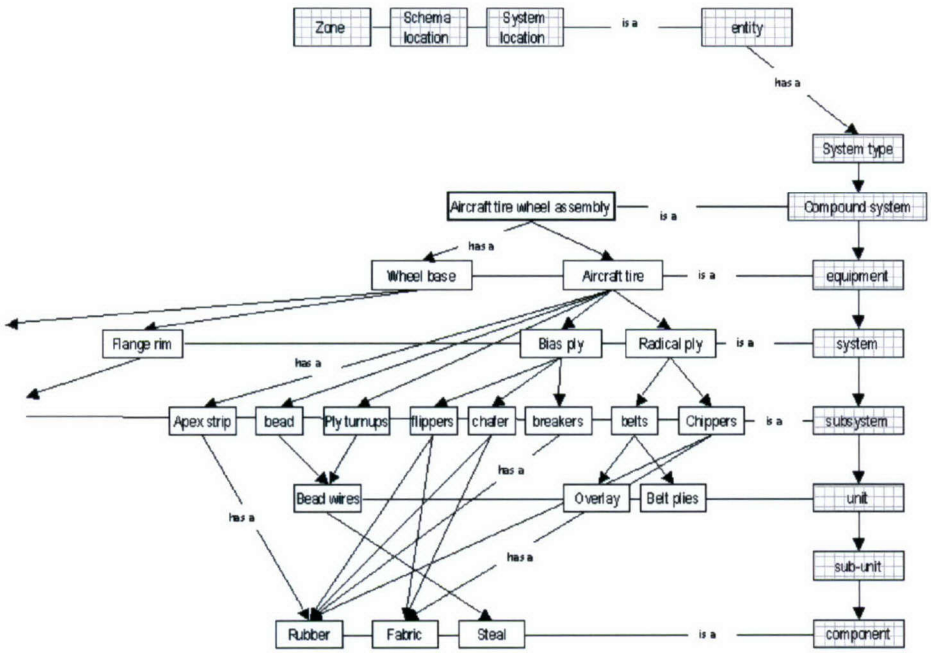

Figure 3.9: Graphical representation of a part of the new domain ontology

The graphical representation of the ontology served as reference material when adding the ontology to the IMAT tools and discussions later on.

Finally, in order to load the ontology in the AIDAS tool, the domain ontology needed to be converted into a CML-file, meaning that the set of domain concepts (as represented in the graphical representation) needed to be represented in the Conceptual Modelling Language. We tried to use the ontology development tool in AIDAS to create the new ontology. This ontology development support tool that is integrated in the IMAT tools was developed to assist the creation and modification of domain specific ontologies. The figure below gives an overview of the Ontology Development Support Tool, depicting parts of the new domain ontology for aircraft tire maintenance.

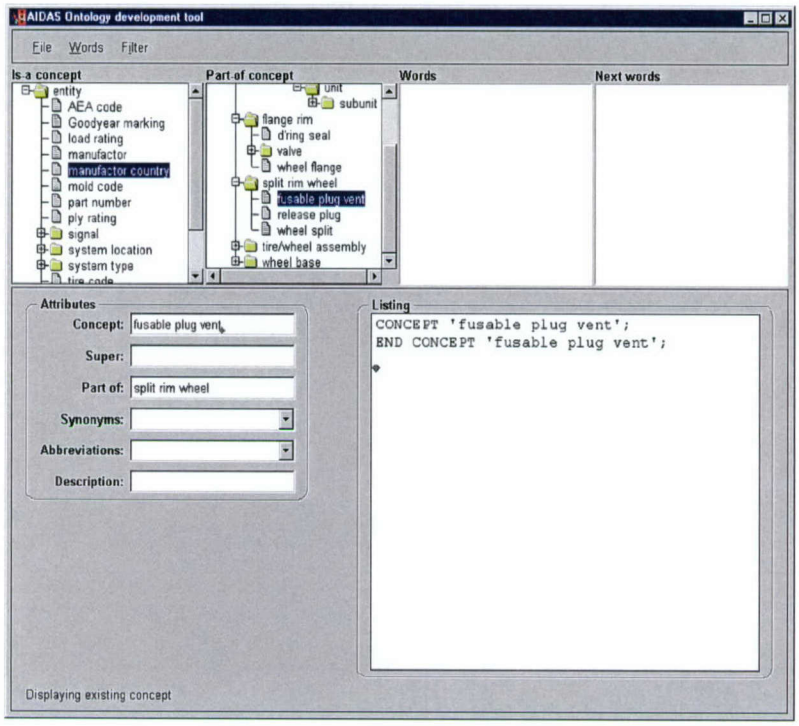

Figure 3.10: Ontology Development Support Tool: showing parts of the new domain ontology

It however appeared that the editor suffers from usability problems. The main problem was that the editor does not provide a complete overview of the relations between system parts. The window displays four separate browsers; an is-a concept browser, a part of concept browser, a words browser, and a next words browser. As a consequence, contextual information is lacking.

In the end, we decided to create the Conceptual Modelling Language manually by customising the existing CML file that was created for the HAWK domain. Although it proved to be easy to slip up, it appeared not to be so difficult. We learned that it requires much precision in placing the quotes in the programming code. The figure below shows a part of the programming code in the CML language.

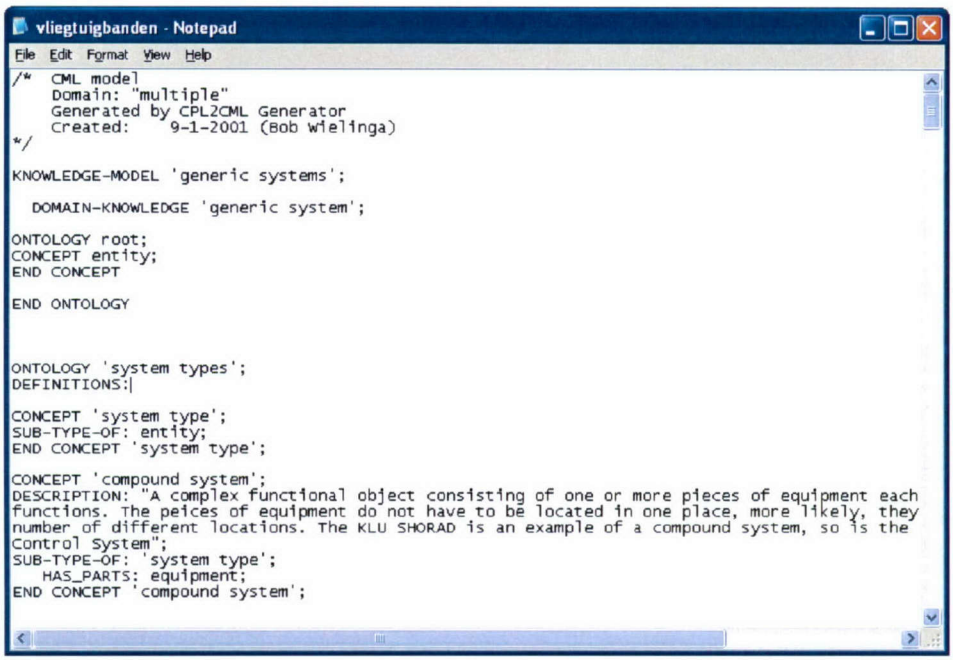

Figure 3.11: Part of the CML programming code

Conclusions on the development of a new domain ontology:

- The creation of a new ontology was not very difficult. It took us about 32 man-hours to create a paper-based version for an electronic aircraft maintenance manual of 49 pages. In reality, the modelling of the domain ontology would be a job for a domain expert who, because of his/her extensive domain knowledge would have little difficulty in modeling the domain.
- The conversion of the paper-based ontology in CML was not very difficult. It took us about 8 man-hours. However, the implementation of the graphical representation of the ontology requires some knowledge of software programming, which will not always be available to the domain experts.
- The ontology development tool in AIDIAS was too difficult to use. It lacks a coherent overview of the hierarchical relations. However, implementing the domain ontology directly in a copy of another domain ontology file was not difficult for someone with programming experience. One has to think of naming conventions and quoting.
- There was not enough support on how to implement more complex relations: Firstly, the example ontology of the HAWK domain that was available did not define any complex relations (e.g. location relations). And secondly, there was no manual available that provided guidance on this issue.
- Also, there was not enough support for how to deal with task-oriented manuals, like the aircraft tire manual. Where the table of contents of system oriented manuals reflects a hierarchical decomposition of the system, the table of contents of the aircraft tire manual reflects a decomposition of maintenance tasks. Although the latter situation is more ideal from an instruction

perspective, it is harder to create an ontology on the basis of such a manual (note that in an ideal situation the expert uses the table of contents of the manual as the basis for creating the system ontology).

3.2.5 Adding new domain files to IMAT directory

The next step was to upload the CML file together with the aircraft tire manual in the AIDAS tool. This section describes in detail how we added the new domain to the IMAT directory. Note that the drive and directory names are specific for the software configuration that we used, and will be different on other PCs.

3.2.5.1 Create a new domain directory

On the D-drive of the computer was a directory called IMAT (D/IMAT). The folder contained two subdirectories, 'applications' (D/IMAT/applications) and 'Pfinal' (D/IMAT/Pfinal). The applications folder contained domain specific files (like ontologies, source documents, DAS files) for several domains. The Pfinal folder contained the program files to run the IMAT tools. We created new subdirectories in the applications folder, which were called: 'das', 'document_status', 'images', 'indexes', 'odlql', 'ontology', 'source_documents', 'text_fragments', 'transformed_documents', and 'xml'. We found out that an easy way to create the new domain directory was copying one of another domain directory, pasting it in the applications directory and renaming it. After having given it the new domain name, the 'read only' attribute was turned off in the folder settings (available via the right mouse menu: select 'properties' and deselect the 'read-only' attribute from the general tab).

3.2.5.2 Add a new source document

For adding the new source document (the aircraft tire manual) to the AIDAS tool, we opened the directory D/IMAT/applications/source_documents, deleted all existing source documents in the folder and pasted the new source document (the PDF-file) in the corresponding subdirectory. Note that the tool does load PDF and XML files (depending on type), but no Word files.

Add CML file
In order to add the new ontology to the AIDAS tool we opened the directory D/IMAT/applications/ontology, deleted the existing files in that folder and added the new CML file to directory.

Fine tune DAS file
Finally, the DAS file needed to be fine-tuned. The DAS file was located in the directory D/IMAT/applications/das. The main task was to make the DAS file call (activate) the new domain ontology. For this reason, we customised the program code in an existing DAS file: We opened the DAS-file and replaced the name of

the CML-file in the top-line of the code (see figure below: Replace 'vliegtuigbanden.cml' by the name of your new CML-file).

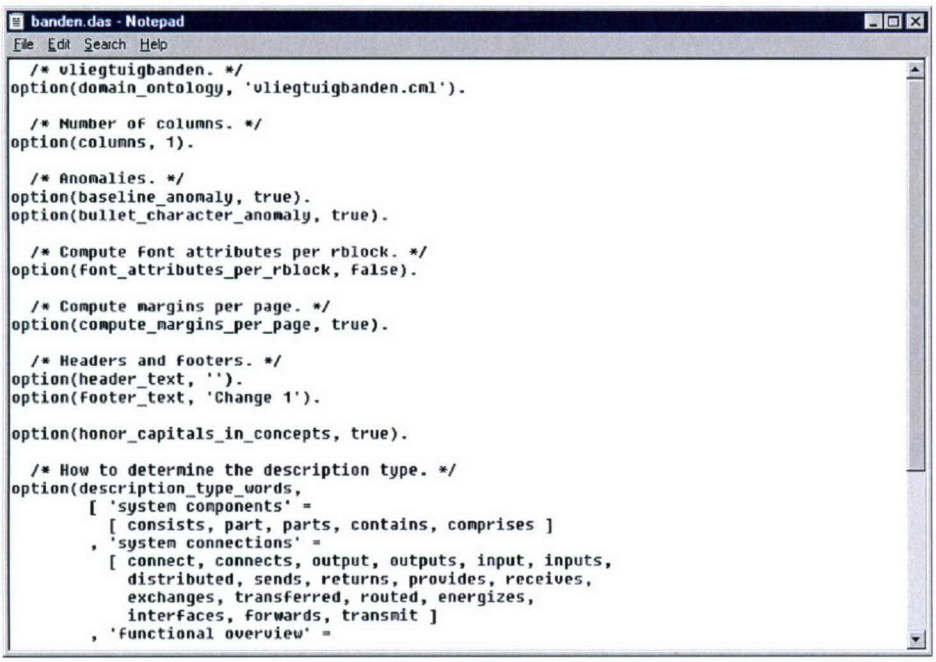

Figure 3.12: Program code in the DAS file

3.2.6 Uploading the ontology to start text and image analyses

The next step was to start the text analysis of the new manual using the new ontology. To load the new ontology in the AIDAS tool, we changed the 'context' setting into the new domain context; 'banden'. When having set the context, the ontology loads automatically.

By looking in the SWI-Prolog screen, we were able to check whether the ontology indeed was loaded. The Prolog log file however does not provide feedback about all relevant actions, e.g. the Log file does not always show that the CML/Das file is loaded. The next figure shows the AIDAS menu for loading the ontology plus the SWI-Prolog code.

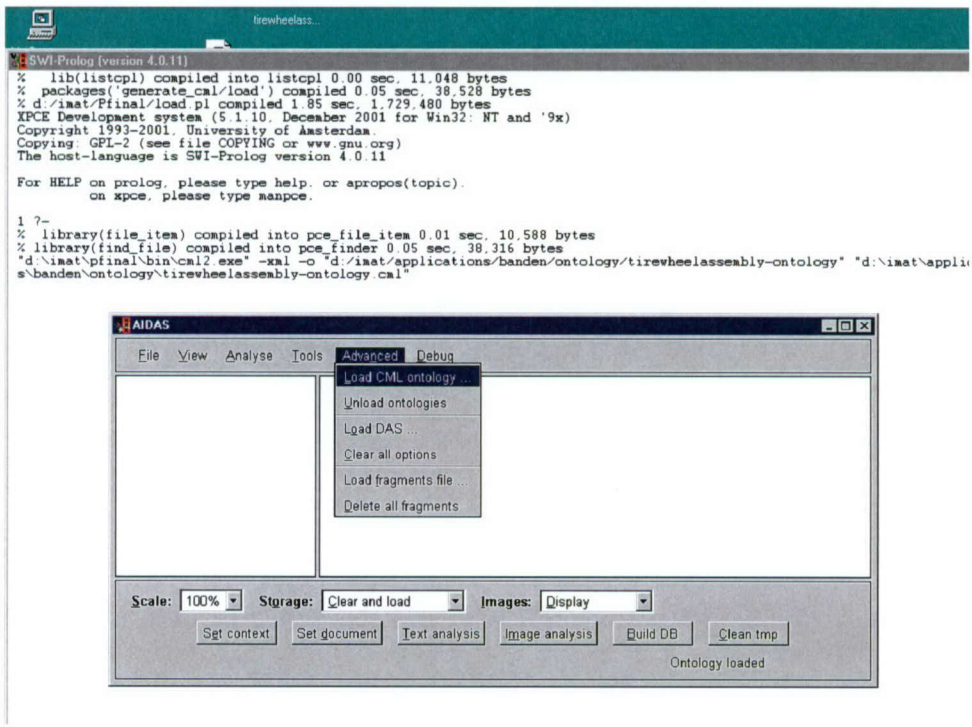

Figure 3.13: AIDAS menu for loading a domain ontology

Next, we loaded the PDF manual by selecting the set document button, selected the document and the page numbers that we wanted to be analysed. In order to save time we selected a limited number of pages. During the analysis process, we were confronted with some faults in the programming code of the CML file. All faults that were found concerned incorrectly placed quotes. With some help of one of the implementers of the tools (from ISLA at the University of Amsterdam) we were able to correct them.

Due to the fact that AIDAS does not provide meaningful error messages, it was hard to track down simple faults in the CML-file, like incorrect quotes, typing faults, and spaces in titles. For this reason it appeared better to experiment with a restricted number of pages first (by setting the page range), until all errors were fixed.

The text and picture analysis was not successful. The picture analysis did not work and the text analysis did not produce correct results. The figure below shows a result of the analysis. It appeared that the tool is very sensitive for the quality of the PDF-file.

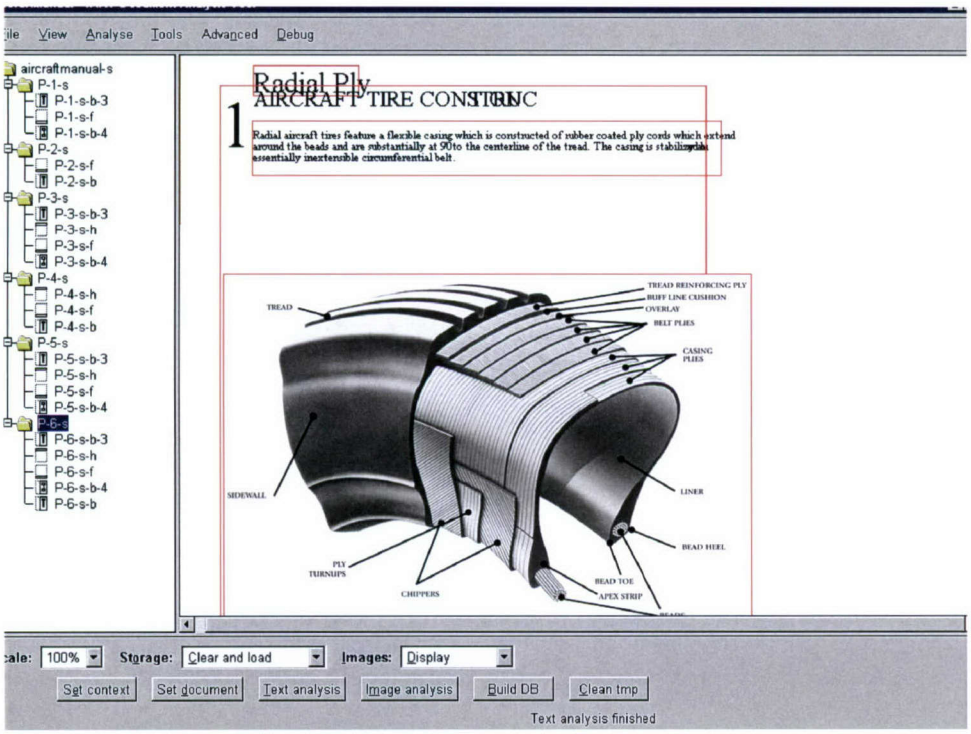

Figure 3.14: Results of the text and picture analyses in AIDAS

Since the fragmentation process did not succeed, we were not able to store any indexed fragments in the Jasmin database.

The conclusions of the document analysis process are:

- The interface of the AIDAS tool is not very easy to use. It is not obvious how a new domain ontology can be loaded, nor meaningful error messages and feedback on user actions is given. Additionally, the IMAT manuals do not provide help on this. For this reason, it takes a lot of effort to find out what actually is the problem. Only users with programming experience will benefit from some feedback provided in the SWI-Prolog screen. In order to save time, while testing a new CML-file, it is recommended to start the analyses with a restricted number of pages;
- So far, the document analysis has not produced correct results (fragments) from the structure and text analysis. Given the type of problems, the expectation is that with some help of ISLA further fine-tuning of the DAS file will be necessary to obtain proper results of the structure and text analysis. This should be done by AIDAS experts and given the type of problems as well as the well defined and structured format of the air tire manual this did not appear to be problematic at the time of writing of this report;
- The picture analysis did not work, probably due to the extensive grey scales of the pictures in the air tire manual from Goodyear (most common error reference type in AIDAS was "picture is too grey"). Problems with the image analysis have not been resolved during the writing of this report and at this point it is not

possible to give a proper estimation on the exact scale (major or minor) of these problems.[7]

3.2.7 Retrieving fragments

The next step in the new domain implementation process would be to retrieve the stored fragments from database and to see whether instructional authors would be able to find and use the fragments about the desired topics. However, given the fact that the fragmentation failed and no new domain fragments were stored in the Jasmine database, this part of the study could not be performed with the new domain. The ideas described below are based on findings during the tool's evaluation study plus the results of the evaluations performed at GGW De Peel during the European IMAT project (Verstegen, Veldhuis, Staalstra & Hendriks, 2001).

Indexing of fragments
The AIDAS tool stores the fragments according to topic, based on the structure of the document and the topics in the domain ontology. As described earlier, the domain ontology solely describes the system compounds and the relations between them. This normally corresponds with the structure of the electronic technical manuals for system maintenance. However, the aircraft tire maintenance manual is written from a task-perspective and is structured according to the tasks involved for several system parts. Because the generic IMAT domain ontology is limited to representing structural relations between system compounds, the relations between the maintenance tasks and the system parts (as described in the manual) could not be incorporated in the domain ontology. However, to support searching in a maintenance context, the fragments may also need to be enhanced with metadata on *how the fragments are used in a maintenance context*. During the study, the question came up whether indexing of fragments according to system compounds would be sufficient for the aircraft tire maintenance manual. We suspect that the task-oriented descriptions in the manual can be very relevant for searching in a maintenance context. In the future, it may be interesting to consider an additional task-part added to the system ontology.

Adding mark-up
It appeared desirable to add mark-up on instructional intentions. The instructional ontology can be used for this purpose. It allows indexing of fragments with a role-based mark-up, about the way the fragments are going to be used in instruction, e.g. 'is a fragment on tread wears', 'can be used as an example inspection task'. Also here, we suspect that, the indexing of fragments according to maintenance task involved (as described above) would support the users in the process of retrieving the right fragments and to add the mark-up.

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7 ISLA and the University of Amsterdam continued to work on picture analysis (outside the scope of the IMAT projects) and have developed promising solutions to enhance the quality of picture analysis.

Using instructional bags
More likely however is, given the results of the GGW de Peel study, that instructors will use instructional mark-up to enhance larger chunks of learning material such as the instructional bags.

3.2.8 Exporting fragments

Exporting fragments (manually) is supported in various ways in the IMAT tools and appears to be very easy. The results of the user evaluations of the GGW de Peel and other participating countries in the European IMAT Project also confirm this (See Chapter 2).

3.2.9 Conclusions

How difficult is it to create a (new) domain ontology?
The creation of a new ontology was not very difficult. It took about 32 man-hours to create a paper-based version for the aircraft tire manual of 49 pages. With a little testing support of ISLA it turned out to be not very difficult to implement the new domain ontology into a CML file, and load this in the DAS file for the new domain.

How difficult is it to implement a (new) domain ontology in the tools?
It is rather surprising, however, that the manual manner of implementing and building an ontology (as described above) is easier than using the ontology development support tool. This tool certainly lacks, especially a graphical representation view of a complete ontology. The user-interface (and user manual) need extra attention in the area of usability (it takes quite some time to find out how to add a new concept). After these usability modifications, adjusting and adding new concepts to an existing ontology is expected to be easier and less error prone via this tool.

How difficult is it to tune the AIDAS tools to new source material?
Usually, a domain specialist will do the development of a domain ontology, and the necessary time and effort will depend on the complexity and size of the new domain (amount of concepts, keywords and relationships). However, our expectation is that time spent on ontology development will after an initial "peak" of necessary hours, require only relatively few hours to maintain and adjust the domain ontology when changes in the domain occur. The real challenge is to determine the correct level of detail in the domain ontology, enabling optimal retrieval of fragments. In essence this comes down to establish a return on investment on the amount of time (and money) spent versus the attained level of detail in a domain ontology enabling fragment indexing, search and retrieval.

How difficult is it to get the text and image analysis working in a new domain?
We learned from the new domain implementation that the document analysis (both text and pictures) still requires some fine-tuning to be able to get correct results (fragments) from the structure and text analysis. The picture analysis remains problematic, probably due to the extensive grey scales of the pictures. The domain ontology is loaded without problems for the new domain context.

System-based versus task-based manuals
Very often, technical manuals for system maintenance are written from a system-oriented perspective instead of a task-oriented perspective. Although the latter situation is more ideal from an instructional point of view, it is harder to create an ontology on the basis of such a manual because the table of contents is not directly suitable to use as means of input for domain ontology development. However, to support searching in a maintenance context, it seems desirable to enhance fragments with information on how they are used in a maintenance context. These annotations can be added manually using the instructional ontology. This process would be supported by an index of fragments on maintenance task involved. For this purpose, it is interesting to study the possibility of enhancing the domain ontology with a task-part, so that an additional task index can be generated.

4. Relevant RNLAF factors for the use of IMAT

This chapter gives an overview of the first part of the factor study, i.e. an inventory of educational, technical and organisational factors, in relation to the possible use of IMAT solutions in the RNLAF. Chapter 5 describes the second part of this factor study, which consists of the development of factor models. Models are developed to get a clear view of relationships between relevant factors and their influence on the technical training process with use of IMAT solutions in the RNLAF.

The factors have been generated by means of desk-research. Input for this study was a literature study (See: list of references), project members' knowledge of the RNLAF through TNO research projects for the RNLAF in the field of training and education, such as IETM, IMAT, MTTP and e-learning. Furthermore, organisational knowledge on the RNLAF was gathered through a special RNLAF course (duration of six days) for TNO researchers. Finally, a symposium on the RNLAF educational policy for the (nearby) future was attended.

4.1 Context Description

Within an organisation as the RNLAF strong demands are made upon the quality of training and education. Training and education, especially in the field of technical training, comprises the training of crucial, critical and often safety risk skills, knowledge and attitudes.

For an organisation such as the RNLAF it is crucial to determine the advantages and risks of a full-scale implementation of IMAT tools in a new domain, especially since the benefits of IMAT tools lie in technical domains with huge amounts of (changing) technical content. Therefore it is important to know how the IMAT tools can be used by the RNLAF and which implications, guidelines and advice concerning the use of IMAT tools can be derived from the research in the IMAT and IMAT follow-up project. First thing to know is how the IMAT Pfinal[8] tools work and what needs to be done for a new domain implementation in the RNLAF. This was described in the previous chapter.

A second step is to determine and study relevant factors affecting and involving the use of IMAT tools in the RNLAF context. However an important distinction can be made between the IMAT tools as they are now, or ideal IMAT tools. Since the European IMAT project delivered an advanced set of prototypes, methods and knowledge on the integration of manuals and training, it is important not to limit the discussion on the possible use of IMAT tools as they are now. For future use

8 Pfinal is used as description for the final set of tools developed in the IMAT1 project.

within the RNLAF it is worthwhile to look beyond the possibilities of the current prototypes and take also an ideal set of IMAT tools or IMAT kind of solutions into account.

4.2 Factor Overview

Any organisation considering the use of technology in training, either to design and develop training or to transfer training, will have to think about the consequences and relevant factors of putting the technology into best use. In our view three main perspectives have to be taken into account. They are education, technology and organisation (ETO). By this we mean that from these three perspectives one has to think about the factors affecting and involving the use of advanced technology in training. The next figure gives a graphical representation of the ETO framework to study the use of IMAT tools and solutions for the RNLAF's technical training domains.

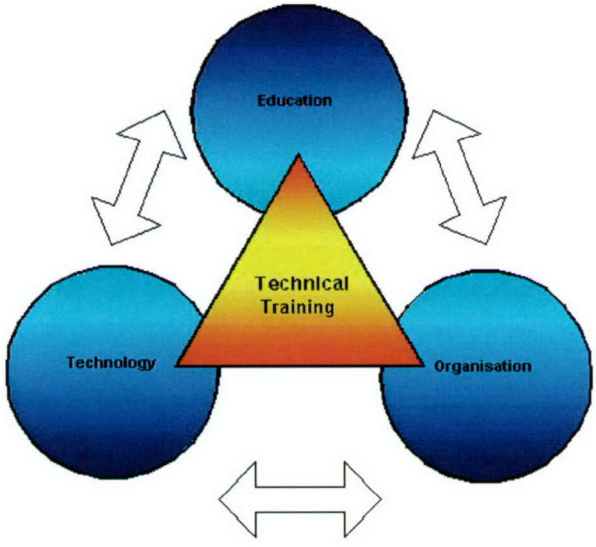

Figure 4.1: ETO framework for the study of factors involving the use of IMAT tools for technical training in the RNLAF

Further analysis was necessary to determine which factors play an important role from each ETO perspective. The results of this analysis are described in the next sections, and from each ETO perspective relevant factors for the use of IMAT tools in the RNLAF context are listed.

4.3 Educational Factors

In the RNLAF, from an educational point of view, many interesting developments are taking place in the field of technical training. For the RNLAF, training and education are keystones of their organisation. Although this could apply to any

high tech organisation, for the Netherlands Armed Forces (Royal Netherlands Army, Royal Netherlands Navy, Royal Netherlands Airforce and the Royal Netherlands Military Police) this goes even further: their key mission during peacetime *is* training and education. To be able to participate in crises, peacekeeping missions and times of war, military organisations need constant preparation, training and education to comply with the high demands made by military operations throughout the world.

4.3.1 Technical training characteristics

In general, technical training can be defined by certain characteristics (Barnard, et al., 2002). This section gives an overview of these characteristics, since they also apply to the RNLAF. The main characteristics and problems in technical training are:

- Training is aimed both at the acquisition of procedural knowledge and skills as well as complex cognitive skills, such as troubleshooting.
- Technical training is often related to crucial, critical, and risky or hazardous work (such as aircraft maintenance) and is therefore very organisation and equipment specific.
- Training is a mix of theory and practice, and should preferably take place at or near the maintenance site, such as the workshop or maintenance hangar.
- Training needs to be accurate and up-to-date: this is a challenge since technical systems and their components change very rapidly.
- There is no training material available on the market; companies need to develop and maintain their own training material.
- Training developers and instructors are often technical experts with insufficient didactic expertise.
- Technical specialists need constant training and re-training because of rapidly changing technologies.
- Technical training courses usually have a very limited number of trainees.

4.3.2 Centralisation of training

A few years ago, the RNLAF decided to centralise most of the training activities, such as basic military training, initial pilot training, and initial function related technical training, such as aircraft maintenance at the Royal Military School (Dutch abbreviation: KMSL), located at the airbase of Woensdrecht. The centralisation of training has led towards an increasing number of students on one hand, and a shortage of instructors at the Royal Military Airforce School on the other. Therefore, the RNLAF is currently reviewing various options, such as e-learning, training on the job, and outsourcing, to create and maintain an efficient and effective training program for technical specialists.

The IMAT tools can be used in different ways by an organisation. Therefore, several scenarios on the possible use of IMAT will be developed for the RNLAF.

This will be described in the second IMAT report (Janssen, et. al., 2004). The IMAT tools can, for instance, be used at one central location where training material is developed. This training material can then be distributed to instructors and students at various locations within the RNLAF.

4.3.3 Leerbedrijven[9]

The RNLAF will start with the implementation of so-called "leerbedrijven" at various bases of the RNLAF for all (function related) technical training, apart from the initial (function related) technical training at the KMSL in Woensdrecht. These schools will act as intermediaries between the initial technical training at the KMSL and training on the job at the operational airbases.

4.3.4 Training on the job

After initial training at the KMSL, technical specialists receive further training on the job, under guidance of a master, at the squadron of the assigned airbase. This results in a heavy burden on the maintenance capacities of an operational squadron, due to the shortage of sufficient experienced staff to fill in both the demands made by the training on the job of novices and maintenance activities requiring a high level of expertise. The IMAT tools could be used in "a training on the job scenario", where demands on the master could become less if specialists could also use self-study learning materials, created for instance with the IMAT tools.

4.3.5 HIVO[10]

HIVO is a Dutch acronym for the project that currently reviews all the initial function-related technical training of the RNLAF in order to develop a more congruent curriculum for technical specialists. Until now, the curriculum for technical specialists comprised a broad and extensive theoretical training at the KMSL, combined with practical training on live mock-ups of fighter jets and engines. For some disciplines, the KMSL also uses advanced simulation-based training methods. After the initial training, specialists receive further training on the job at the assigned airbase.

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9 This is a Dutch name for schools located at the airbase for (function related) technical training.

10 HIVO: Herziening Initiële Vaktechnische Opleidingen.

Problems identified with the current curriculum for technical specialists are:

- Strong fluctuation in instructor capacity at the KMSL (varying from under to overcapacity);
- Too great a distance and differences between training in the school and training on the job;
- Technical specialists receiving longer, extensive and broader initial functional training than needed for their initial functions;
- Shortage of masters at the operational airbases.

Although there is not a direct link between the HIVO project and the IMAT follow-up research, it is good to realise and understand the background factors underlying the HIVO project. They can hold important implications for the use of IMAT tools within the RNLAF. However, results from this project were not available during the IMAT follow-up research.

4.3.6 Simulation-based training

The RNLAF uses both high fidelity simulations and medium fidelity type simulations (Jacobs, van der Hulst & van der Stigchel, 2002) for the instruction of technical specialists. At the Royal Military School, for example, (live) mock-ups of F-16 fighter jets and F-16 engines are used in a practice environment to learn basic maintenance skills. For avionics specialists in training for F-16 maintenance, in an advanced medium fidelity type simulation-based training environment, the so-called Avionics Technical Training Package (ATTP) is located at the school's premises. A similar simulation-based training environment, the Mechanical Technical Training Package (MTTP), is currently under development for F-16 system maintenance specialists. The RNLAF conducts the development and procurement of both training packages in a partnership with the Norwegian Airforce.[11]

At the main operating bases of the RNLAF, so called Unit Level Trainers (ULT) are located at the squadrons. These high fidelity type simulations are not only used for F-16 pilot training but also for the training and licensing of technical specialists, who have to conduct maintenance activities in the cockpit of the F-16.

Although the use of simulations holds many advantages for the effective and efficient training of technical specialists, the RNLAF currently faces many challenges in keeping the training materials of their simulation based environments up to date with the changes in the core systems of the F-16 and their technical

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[11] Several European Airforces (EPAF) have joined in a "F-16 partnership" to work with each other on matters of procurement, logistics, maintenance and training. Rationale behind this partnership can be summarised as forming a strategic alliance, and achieving mutual adjustments in logistics, maintenance and training. This leads to better and closer co-operation during NATO missions, e.g. enabling Dutch technicians to work on Belgium F-16's and vice versa. EPAF partners are Belgium, Denmark, Norway, Portugal and The Netherlands.

manuals. Since the source material for these training simulations are regularly changing and updated technical manuals, the IMAT tools could provide a possible solution in keeping the training material for simulations accurate and up to date in a better and easier way.

4.3.7 E-learning

Within the RNLAF e-learning is not necessarily seen as a better way of transferring knowledge, but seen as a possible solution towards the effective transfer of training as well as an opportunity to provide training modules which can be studied by students anywhere and anytime. For instance, e-learning could facilitate (re)training on the job.

E-learning is an educational technology closely connected to the possible use of training material created with the IMAT tools and is an important educational factor to take into account when thinking on future IMAT solutions for the RNLAF.

4.3.8 ADL-SCORM

The RNLAF decided to follow the ADL SCORM guidelines for the standardisation of e-learning content (Hylkema, 2001). It is therefore important for the RNLAF to know whether the IMAT tools can deliver ADL SCORM compliant e-learning content. The ontologies used in IMAT for the indexing of fragments, or in other words to add metadata, were developed with a close eye on the work done in projects as Ariadne, IMS, LOM and ADL-SCORM.

An IMAT/ ADL-SCORM investigation by TNO (Veerman, et al., 2002) showed that differences exist in the naming of metadata fields and also in the type of fields. The IMAT didactic indexing, for example, is far more extensive than the didactic indexing provided by SCORM. Both SCORM and IMAT use XML, and although IMAT XML files cannot be used directly by SCORM, the database structure seems appropriate to create a link with SCORM.

To create SCORM-compliant IMAT solutions, obligatory and missing SCORM metadata fields should be filled in by IMAT. By using mapping techniques and creating profiles this problem can be addressed. The extra metadata provided by IMAT can also be used. The metadata fields that are obligatory by SCORM should be made available via an extra (IMAT) module that should be developed. This extra module can provide an exchange platform for fragments and metadata through a SCORM XML connection. For a future existence of IMAT in the RNLAF such an exchange platform is essential. The advantage of developing an extra IMAT/SCORM XML module is that in the future only this module will have to be adjusted in case XML specifications change. See Veerman, Veldhuis, Jacobs & Strijker (2002).

4.3.9 Outsourcing

Training outsourcing could be applied to:

- Technical training as a whole: Students would be trained outside the company or an external organisation would provide training within the company.
- Technical training development: For the development of advanced training solutions such as computer-based training (CBT), simulation and web-based training (WBT) one may consider outsourcing the development function to respond to a possible lack of expertise.

Outsourcing of training can provide an alternative for instructor capacity problems at the Royal Military School; though this alternative certainly cannot be applied to all technical training that is very specific and closely adapted to the systems in use by an organisation. In the Netherlands, F-16 configurations, for instance, differ substantially from F-16 configurations in other countries. Also differences between the organisation of maintenance work in the RNLAF and foreign airforces sometimes prevent outsourcing being a good alternative. Finally, the military saying "today's friend can be tomorrow' s enemy" suggests certain risks in outsourcing critical and specific technical training.

Outsourcing of training development could provide a solution to fill any gap in expertise; though this will not necesserily mean that it is cheaper or better for an organisation such as the RNLAF to follow this path. Especially in the field of technical training, extensive domain-related knowledge is required. Outsourcing training development would still require a substantial contribution of RNLAF's technical and domain expertise. This was, for instance, the case during the development of the ATTP. Furthermore, the same arguments as described in the previous section can be made against the outsourcing of training development regarding the specificity and confidentiality of technical systems and their system knowledge. Finally, in technical training, material needs constant revision to keep it up to date and accurate. This implies that a certain amount of training (re)development always will always have to take place within the RNLAF.

For the RNLAF, it is therefore important to have tools available supporting effective and efficient training development. This is especially the case for technical training and the development of advanced training solutions such as simulation-based training and e-learning. The main objective of the IMAT tools is to provide automated and structured support in the process of creating training material from technical documentation.

4.3.10 Summary

The previous section described these educational factors:

- Technical training characteristics: important characteristics for technical training and possible use of IMAT tools.
- Centralisation of initial technical training: at the KMSL in Woensdrecht.
- Leerbedrijven: schools to be founded at airbases in the near future.
- Training on the job: important focus for technical training in the RNLAF.
- E-learning: an important factor for technical training in the RNLAF closely related to the possible use of IMAT solutions.
- Simulation-Based Training: an important training mechanism for technical training in the RNLAF closely related to the possible use of IMAT solutions.
- HIVO: a project that reviews all initial function-related technical training.
- Standards: ADL-SCORM, adapted by the RNLAF for standardisation of metadata for electronic content.
- Outsourcing: possible solution for technical training and/or technical training development with important consequences for the RNLAF and possible use of IMAT solutions.

These educational factors are reviewed further by the development of factor models in the next chapter. The development of models assists the process of determining the relative importance of factors for the RNLAF, relationships between factors and their influence on the possible use of IMAT solutions. The factor models give a clear view of the relationships between educational and other factors. The models also enhance knowledge on how and where the factors influence the technical training process in the RNLAF with use of IMAT tools.

4.4 Technology Factors

Technical factors are a basic condition for success or failure of a technology-based training solution. Failing technology will prevent successful implementation of technology-based training solutions in an organisation, especially on a large scale. So it is important to identify and quantify relevant technology factors and their influence on the possible use of IMAT in the RNLAF.

4.4.1 Reliability

Any training solution involving technology should address the issue of reliability. By reliability is meant the technical reliability of tools and technical solutions. This is a important factor in the use of IMAT tools as huge amounts of technical documentation are the basis for the development of (electronic) training material. Reliable technology is a prerequisite to be able to work with IMAT tools.

In the IMAT context it is crucial to have a document analysis tool such as AIDAS, which is fully reliable in creating and retrieving fragments. A second important factor is the reliability of the database and the way data is handled and stored. A corrupt database would be a nightmare, especially in large and extensive technical domains.

4.4.2 Reusability

The concept of reusability was central in the definition of the IMAT project and is crucial to determine the usability of the IMAT tools. Within the IMAT context reusability can be defined in several ways. For example: the reusability of fragments, instructional bags and annotations, but also the reusability of ontologies and knowledge. The latter two are examples of reusability of concepts and knowledge. The first type of reusability, concerning the reuse of fragments in various lifestages, is more technical in nature and requires version management and a (semi)-automatic IMAT tool change and update process that will enable the reuse of content.

For the RNLAF, it is essential to determine how the reusability provided by the IMAT tools answers problems in training development for technical domains and to determine which improvements on this matter within the IMAT tools are necessary or desirable.

4.4.3 Technology level

The use of advanced technology in training also means that one has to consider the level of technology competence of the organisation. By this we imply that, both at the organisational level and at individual level, a careful analysis has to be made whether or not an organisation is capable of implementing technology-based solutions. The analysis must also include an inventory of actions to be taken, such as end-user training, reorganisation of infrastructure, or innovation and change management to come to a successful implementation. This is especially the case for large-scale technology solutions such as e-learning or IETM implementation.

For the use of IMAT tools in the RNLAF, it is advisable to make at least a quick scan of the technology level of involved organisation parts and the technology level of involved people in various functions and roles (students, developers, instructors, management, etc.).

4.4.4 Infrastructure

Some years ago the RNLAF created a confidential network connecting all locations within the Netherlands abbreviated in Dutch as KLUIM. With the implementation of KLUIM so called KLUIM desktop configurations were installed following the LAN 2000 standard and KLUIM standard. The LAN 2000 standard ensures that

each desktop computer and laptop configuration is, to a large extent, the same. The KLUIM standard enables the connection of LAN 2000 computers in a single and large secured network. Through this network (an intranet) it is possible to exchange information and messages in a secure way.

Through the implementation of the KLUIM and LAN 2000 standard, the personal computer has become more and more a company computer. The organisation determines which software is required in certain functions and how the configuration of a computer is set up. One advantage is that new software releases and updates can be done automatically by the ICT maintenance organisation at a distance. The Defence Telematics Organisation (DTO) is the organisation responsible for ICT maintenance, software releases, change and updates and the security of the network for the entire Netherlands Armed Forces.

For end-users, the implementation of KLUIM means that there is no longer a need for their own PC. All data is stored at the centre and users are able to retrieve this data after logging in on any KLUIM PC. Back-up and storage of data are made automatically by the system managers. Disadvantages for end-users are that it is impossible to install software individually and provide Internet acces from these PCs. The latter, however, can be done from separate stand-alone machines.

Other matters relevant to the KLUIM network include the fact that security rules and high costs of installation, change and updating by DTO of (new) software releases have prohibited, so far, the use of advanced training solutions such as the ATTP simulation-based training over various locations.

The features of a confidential network can lead to consequences for successful implementation of a technology-based training solution such as IMAT, and need to be closely studied and defined, especially in scenarios considering a network-centric solution for the use of IMAT tools.

4.4.5 Data Security

Although this is closely related to the previous factor, it is important to realise that data security is necessary due to confidentiality and classification[12] of source material (such as technical manuals or training material). Although the RNLAF network is a confidential network (an intranet with datasecurity) classified information is not allowed on this network.

In the case of working with IMAT tools outside the RNLAF network, for example online, wireless or at locations outside The Netherlands, datasecurity will become

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12 Classification of source material is in the RNLAF divided over various classes. In technical domains source material is very often "business confidential". In the RNLAF certain information is classified, resulting in stricter regulations concerning the distributions and use of this material.

an issue, as well as in The Netherlands when classified material is used and needs to be distributed (electronically).

Consequences for the use of IMAT will depend on the classification of the source material and whether training material needs to be distributed outside the RNLAF network though this does not seem very likely. An interesting question is when data security is necessary, whether data security should be integrated in an IMAT solution or should be addressed in the distribution process.

4.4.6 Summary

The previous section described these technical factors:

- Reliability: technical reliability of IMAT tools.
- Reusability: reusability of fragments or electronic content in general.
- Technology level: a factor to take into account in the implementation of IMAT tools in a certain part of the RNLAF organisation.
- Infrastructure: an important factor to take into account in the implementation of IMAT tools.
- Data Security: an important factor in case source material is classified.

These technical factors are studied further, together with educational and organisational factors through the development of factor models, in the next chapter.

4.5 Organisational Factors

Many organisational factors (at various levels) have to be taken into account when an organisation considers the use and implementation of a technology-based training solution such as IMAT. Although this is no different from more traditional training solutions, the use of technology can have other implications for an organisation such as described in the previous and current section.

4.5.1 Airpower

Airpower is the "main product" of the RNLAF and can be seen as the central organisational mission statement from an organisational point of view. Although there is no direct link connecting the use of IMAT tools with this central mission, training and training development solutions such as IMAT will all lead to an effective and qualified organisation able to fulfil this key mission. Seen from this perspective the key mission of airpower is also closely related to the technical (training) domain, for which the use of IMAT tools is intended.

4.5.2 Defence organisation

It may appear obvious that the RNLAF is a military organisation. However, it certainly is not a factor to forget especially when training in technical domains is considered as well as the impact of using technology in training. Two examples clarify the importance of this factor:

- Distributed learning solutions (such as e-learning), and
- Confidentiality of learning content.

Distributed and advanced learning solutions within the RNLAF are limited in full-scale implementation due to regulations concerning the confidential network of the RNLAF. The ATTP, for example, had been intended for use at the KMSL and various bases. Due to regulations preventing the use of authoring tools and distribution of "exotic" formats such as multimedia formats, the ATTP nowadays is only used as training package at the KMSL.

Important implications concerning the confidentiality of learning content or training material were described as technology factor *data security* in section 4.4.5.

4.5.3 Aircraft maintenance

The largest technical training domain within the RNLAF concerns aircraft maintenance for fighter jets (F-16), transportation planes, and helicopters. This fact, combined with very interesting developments in this domain, such as the internationalisation of standards for aircraft maintenance and the implementation of (I)ETMs, determine the decision to focus further in this research on aircraft maintenance training within the technical training domain.

4.5.4 Flight safety/ JAR & LE

For an aviation organisation such as the RNLAF, participating daily in missions all over the world, flight safety is a key factor. Flight safety starts on the ground with proper and thorough aircraft maintenance.

The RNLAF follows European standards for the civil aviation industry, the JAR-147 for aircraft maintenance and the JAR-66 for technical aviation training, and an own military standard (LE) derived from civil aviation regulations and military characteristics. The use of weapon systems, for instance, is an important difference between civil and military aviation organisations. Factors concerning the transportation, use, training, and maintenance of these weapon systems are examples of extra rules and standards needed for military aviation organisations.

These standards not only prescribe tasks, procedures and rules for proper flight maintenance and qualification tests for aircraft and their systems, but also have an impact on the training of maintenance engineers. Strong implications from these

standardisation rules are the importance of training (including qualifications) and the requirements and regulations concerning working with up to date technical documentation. Following wrong procedures in "old documentation" can lead to costly maintenance repair faults or even worse, serious damage to personnel. An ideal set of IMAT tools should certainly contain a solution for keeping training material up to date and accurate in an automated and easy way.

4.5.5 (I)ETM implementation

The evolution from paper manuals to electronic manuals started in the technical maintenance field in the early 1990s. Electronic manuals offer many benefits, such as rapid and easy centralisation of data management, conversion management, distribution and storage.

The American Department of Defence started a standardisation initiative (CALS), Jorgensen, 1994) for the development and classification of Electronic Technical Manuals (ETMs) or Interactive Electronic Technical Manuals (IETMs). This initiative has evolved worldwide and led to numerous military standards and specifications for various classes of (I)ETMs. It is nowadays followed mainly by military organisations and affiliated industries in technical systems and technical documentation.

In general terms, an (I)ETM can be described as a package of information used for the diagnosis of technical (weapon) systems, optimally organised and formatted for interactive end-user screen presentations. An (I)ETM can hold information sources in any format, varying from text, pictures, audio and video, in various data structures and data relationships. An (I)ETM usually consists of maintenance procedures, task descriptions, and structured help on troubleshooting procedures, system functional overviews, and sometimes a training view or mode. The five (I)ETM classes are:

1. Electronic indexed pages.
2. Electronic scrolling documents.
3. Linear structured ETMs: content (index, text pictures, etc.) presented in separate frames. User navigation is possible through various search options and hyperlinks.
4. Hierarchically structured IETMs: based upon a relational database for storage of dynamic objects. The user interface is no longer based upon frames and is Windows-based. For the user the largest difference lies in the user-system interactivity and the way a user is guided through steps in a task or procedure.
5. Integrated databases combine the functionality offered by class 4 IETMs with opportunities to connect the IETM database directly with other relevant databases, for instance a training database or maintenance and part databases, to create a complete integrated chain and exchange of maintenance-related information.

(I)ETM classes are not exclusively defined, but generally speaking, higher classes provide extra functionality not present in the lower classes. Furthermore, large differences exist between the underlying architecture and level of interactivity between class 1, 2 and 3 ETMs and class 4 and 5 IETMs The two highest classes both have a relational database for storage of various data elements as dynamic objects. Also, class 4 and 5 IETMs have intelligent tables and dialog boxes, where, based upon user prompts and user-system interaction, the correct next step in maintenance procedures are presented. This facility enables the user to jump directly towards the correct next step in a task instead of following linearly the sequencing of a task. For maintenance it is possible to insert so-called In Process Inspections (IPIs) at desired locations in the (I)ETM, to enable the verification and authorisation by senior specialists.

The next figure gives a graphical presentation of the five (I)ETM classes, as presented by the International Technical Order Digitisation (ITOD). In this figure the two (I)ETMs to be implemented for F-16 maintenance in the RNLAF in 2003 and 2004[13] are marked separately. The RNLAF receives for the on-equipment F-16 maintenance a class 3 ETM delivered by LM AERO; for the off- equipment F-16 engine maintenance a class 4 IETM delivered by Pratt and Whitney.[14]

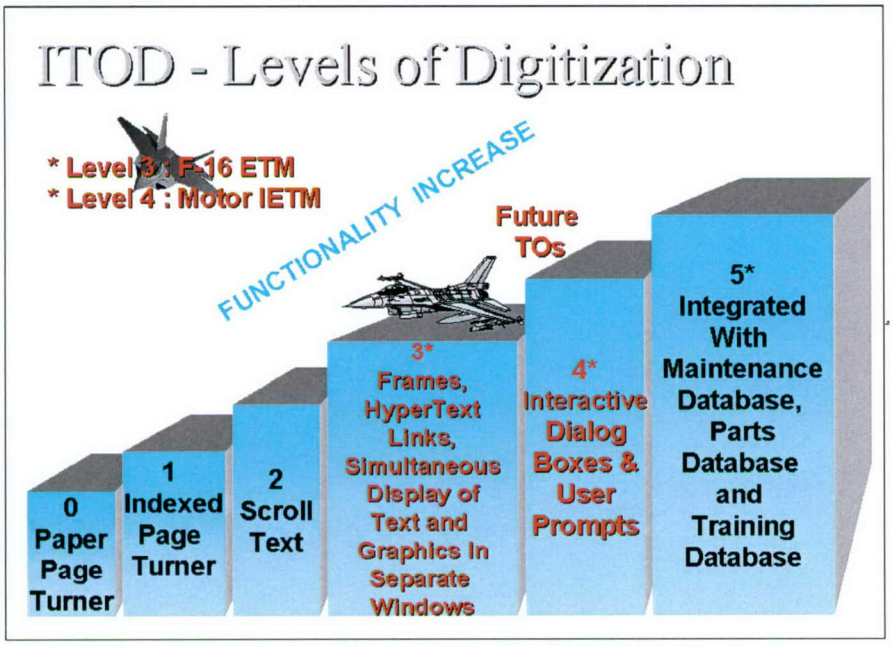

Figure 4.2: Overview of (I)ETM Classes with F-16 (I)ETMs

13 The F-16 system conversion from paper-based manuals to (I)ETMs will probably be completed in 2010. The delivery in 2004 contains the F-16 organisational level manuals only for the F-16 airframe and the intermediate level for the F-16 engine.

14 F-16 maintenance is divided in three levels: organisational (on-equipment maintenance), intermediate (off-equipment maintenance) and depot level maintenance.

Because of the implementation of F-16 (I)ETMs, the RNLAF needs to review and adapt F-16 maintenance, their maintenance organisation, infrastructure and technical training for an optimal implementation and support of the maintenance process with "electronic books" and consequently the use of e-tools by technical specialists. See for more information Riemersma, Bots, van Esch, Jacobs & van der Arend (2002).

In the RNLAF, the first IETM was introduced a few years ago for the maintenance of Apache helicopters. Although the Apache IETM is a class 5 IETM, delivered by Boeing, certain problems regarding the implementation and organisation specific characteristics, such as the extensive use of country peculiar data (so called RNLAF supplements), prevented the RNLAF from an optimal implementation and use of these IETMs so far.

First of all, many representation problems can and have occurred in the Apache IETM as a result of limited presentation options, especially for schemes and drawings. The fact that these are also implemented in an electronic format, and can only be read from a 14 or 15-inch computer or laptop screen, severely hampers instruction and maintenance activities.

Since the RNLAF holds no access to the IETM database it is not possible to add or alter material in it. This has resulted in many problems with Apache maintenance and training. In maintenance, the largest drawback is the fact that it is not possible to add RNLAF supplements in an electronic format to the IETM. This results in "a maintenance support environment" for Apache specialists with the IETM installed on a (ruggedized) laptop, where it is obligatory and very often necessary to check simultaneously the RNLAF supplements (see next section) in paper format, leaving literally no hands free to conduct maintenance.

The RNLAF uses Interactive Multimedia Instruction (IMI) as CBT for technical training of Apache specialists (van de Laak & Boot, 2001). The IMI uses IETM source material but lacks for example an automatic change and update mechanism and does not contain the latest version of the Apache IETM source material.

Other facilities provided by a class 5 IETM, such as automatic changes and updates, connection to a parts and logistics database or training environment, have not been implemented in the RNLAF. In essence, this is due to a lack of putting the technology and maintenance, training and logistics organisation in place, necessary to implement the concept of a class 5 IETM to benefit fully from this solution as maintenance and training organisation.[15] Also it became clear that what is sometimes referred to as training by (I)ETM suppliers certainly does not match

[15] Please note that the RNLAF has 30 Apaches, and therefore only a small number of Apache specialists. This makes concerns with a lack of automatic distribution and updates far more relevant than for the F-16, with hundreds of (I)ETM end-users.

with criteria set for proper training material by instructors and instructional designers.

The implementation of F-16 (I)ETMs and the Apache IETM clearly underlines the importance for the RNLAF of knowing and understanding the parallels and differences between opportunities offered by IETMs and the IMAT tools for technical training and maintenance. This also applies to the consequences for technical training due to the (I)ETM implementation. See for more information: Riemersma, van Berlo & Veldhuis (2002). (I)ETMs offer the delivery of electronic source material, more or less suitable as learning material, depending on the type and quality of the technical documentation. However, this material is written for system maintenance and not always directly usable as training material. The IMAT tools can assist the training development process, and will require with (I)ETMs as input a more simple process of document analysis, although this will also largely depend on the granularity (size of fragments) and type of indexing provided by the IETMs. Main problem with the (I)ETMs is that the RNLAF does not have fully access to the electronic content (stored in a database). Furthermore, the RNLAF, as relative small airforce, has very often no direct contract relationship with the (I)ETM suppliers, and therefore no direct influence on the type and quality of the (I)ETM. In this matter the RNLAF has to depend largely on their relationship with large airforces such as the USAF.

In case source material for technical training is an (I)ETM, IMAT tools should be able to handle the data format of the electronic content as provided. Proper access to this content is essential. For a class 4 and 5 IETM it is important to determine whether the training facilities provided by an IETM offer a training solution and how they should be integrated in the technical training curriculum, or that it remains necessary to develop or procure (extra) training material. When using IMAT solutions, considerable attention should be paid to the architecture in relation to the RNLAF infrastructure and ICT policy. This should be done in combination with defining how to support efficiently technical training (development), system maintenance and change and update management, similar to the pre-investigation of the (I)ETM implementation via KLUIM as anticipated for the F-16 (I)ETMs.

4.5.6 RNLAF Supplements

The RNLAF uses (extensively) so-called RNLAF supplements, especially in the field of aircraft maintenance. These supplements can be described as additional information used along with or instead of the technical system and maintenance documentation provided by the supplier. An RNLAF supplement is always leading the way as to how system maintenance should be conducted and could, for instance, describe temporary procedures and task descriptions (written to compensate for mistakes in the technical manuals), country peculiar maintenance procedures and safety rules.

The RNLAF relies heavily upon the use of RNLAF supplements to conduct aircraft maintenance, due to time-consuming procedures for new releases of technical manuals, concerning changes and updates on mistakes or new procedures. Also, differences between law and regulations in various countries (for instance on the use of tooling, equipment and substances) and something which could probably be described as "organisational knowledge on systems" leads to the extensive use of this type of information. The expectation is that with the ageing of weapon systems the use of RNLAF supplements will not only remain an important factor in system maintenance (and training) but will also increase in importance.

When RNLAF supplements are part of the training material, IMAT solutions should be able to handle this type of information. Currently, the RNLAF supplements for the Apache and F-16 are created in PDF format. The class 4 IETM concerning the F-16 engine maintenance provides a connection with external documents in PDF format through hyperlinks. A reference to the hyperlink is stored in the IETM database, enabling F-16 countries to add country peculiar data to the IETM via a hyperlink.

4.5.7 Availability of personnel

In technical domains in general and aircraft maintenance in particular availability of maintenance personnel is a serious problem. Due to a strong economy in the 1990s and an undercapacity of technical specialists on the job market in the Netherlands, it has been very difficult for technical organisations such as the RNLAF to recruit and keep technical specialists. As a consequence, the RNLAF is confronted with a key staff shortage, resulting in a triple capacity problem in the technical training domain. There is a shortage of:

- Instructors at the Royal Military School,
- Training developers, especially CBT or WBT developers,
- Masters to guide the training on the job of novices.

In all situations, experienced technical specialists are required to do the job. However, their expertise is also needed (even more so) for highly specialised and difficult maintenance tasks, requiring a lot of experience, such as troubleshooting.

It is without doubt the largest challenge for the RNLAF to meet both demands made by operational maintenance work and the technical training necessary to conduct maintenance according to the standards and qualifications on flight safety, and aircraft maintenance. Both operational work and training rely heavily upon the scarce trained and experienced staff and both worlds are equally important for the daily and future operations of the RNLAF.

The use of IMAT tools alone cannot lead to a solution for the challenges described above. However, they could make a major contribution to the problem of how to support scarce expertise within the RNLAF, and lead to more organisational benefits from this senior expertise.

4.5.8 Aircraft availability

This factor is closely related to the central mission statement of the RNLAF and its main product airpower. Partly due to challenges of personnel availability, but also due to problems with parts management, logistics, and other reasons, aircraft availability itself has become a challenge for the RNLAF.

Although it is important to consider which problems are central in an organisation, since training and training solutions can be part of the answer to a problem, this does not seem to be the case for the possible use of IMAT tools in the RNLAF. Therefore, aircraft availability will not be taken into account further.

4.5.9 Reorganisation and budget cuts

These two factors are mentioned here because it is important to realise that the RNLAF faces, together with other defence organisations in the Netherlands, reorganisations and budget cuts. Reorganisations take place through the redevelopment of technical training (HIVO, ATTP and MTTP) as well as in the F-16 maintenance reorganisation at the airbases. As a consequence of budget cuts, serious reductions will have to be made both in personnel and material. These factors, however, are very general and will not be taken into account further while thinking about IMAT solutions for the RNLAF.

4.5.10 Summary

In the previous section, these organisational factors were described:

- Airpower: the main product of the RNLAF.
- Defence Organisation: an organisation characteristic.
- Aircraft Maintenance: the largest technical (training) domain in the RNLAF
- Flight Safety/ JAR & LE: international standards concerning flight safety for aircraft maintenance and training.
- IETM Implementation: an important development in aircraft maintenance and training.

- Availability of personnel: there is a shortage in personnel, both in training and maintenance (also due to budget cuts).
- Aircraft availability: a factor closely related to the RNLAF's main product.
- Reorganisation and budget cuts: extensive reorganisations and budgets are foreseen in the RNLAF.

These organisational factors are studied further, together with educational and technical factors, through the development of factor models in the next chapter.

4.6 General Summary

In this chapter an inventory was made of relevant ETO factors for the possible use of IMAT tools in the RNLAF. To study the relevance and relationships between these and their influence on the technical training process in the RNLAF with the possible use of IMAT tools, factor models are developed in the next chapter. Factor models present an overview of how ETO factors interact and relate to each other and influence the technical training process with use of IMAT tools in the RNLAF. These models will help in determining the relative importance of the factors described in this chapter, related to the possible use of IMAT solutions in the RNLAF.

5. IMAT solutions for the RNLAF

This chapter summarizes the second part of the factor study, which consists of the development of factor models. Models are developed to get a clear view of the relationships between relevant factors and their influence on the technical training process with use of IMAT solutions in the RNLAF. Two types of factor models have been developed and described: a process model and requirement models. The results of expert interviews conducted to validate the factors and factor models are also described. See for a detailed description of the model development: Jacobs, van der Hulst, Verstegen & Janssen (2003).

5.1 Introduction

A next step in the study of factors is the development of one or more models. The purpose of models in general is to simplify reality in order to conveniently study this. As such, a model can be seen as a means to structure knowledge of a specific part of this complex reality. A model can be used to describe and study the reality, but also to predict the effects of a certain change or choice in this reality.

5.2 Why modeling?

In this research, modeling is used in the first place to create a clear view how ETO factors and relationships between these factors influence the possible use of IMAT solutions in the RNLAF context. For this purpose process models are developed. In the second place, modeling is used as a method to define and study the type of requirements and requirement relationships for IMAT on one hand and for the RNLAF on the other. For this purpose so-called requirement models are developed. The construction of these models gives a clear view on the type of requirements, their relationships, and a method for a more detailed study concerning relevant factors, requirements and requirement relationships. This can also lead towards a more detailed advice (as described in the final chapter) on the possible use of IMAT solutions in the RNLAF.

5.2.1 A Systems approach

The approach taken on modeling in this research follows a systems approach (Kramer & De Smit, 1991).

Kramer and De Smit (1991) give the following definition of a systems approach:
1. Identify the whole, of which the subject of the study is part,
2. Explain the behaviour or attributes of the whole.

3. Explain the behaviour or attributes of the subject to be explained, in terms of its role or function within the whole.

In essence, this approach suggests that IMAT solutions should be analysed in the environment they will apply to and thus should be studied as a part of a larger whole. For this research this refers to the educational, technical and organisational factors in the RNLAF context.

System Definition
Kramer and De Smit give, in their book on systems approach, the following definition of a system:

"A set of entities with a set of relationships that exist between these entities"

A system can be defined, according to Kramer and De Smit, as:
1. A set of entities in the system: W.
2. A set of entities in the environment: E.
3. A set of relations between the entities in the system: Rww.
4. A set of relations between the entities in the system and the environment: Rew.

Entities are elements or parts of a system. Sometimes entities are also referred to as objects or elements. Entities are the smallest parts in a system one wants to take into account and assign attributes to. In a process model these entities consist of processes (as black box), products (necessary inputs and outputs) and attributes of products/ processes.

According to set theory this definition of a system (S) can be noted as:

$$S = <W, E, Rww, Rew>$$

In essence, a system description comes down to the establishing (and describing) the four sets and analysing whether a set of entities in the system (W) shows a relationship. To be able to describe a system, one or more models of a system is/are used.

System definition for this research
It is important to describe what is defined as a system, to be studied and modelled, in this research. The system definition for the (possible) use of IMAT in the RNLAF is stated as follows:

"The technical training process in the RNLAF with use of IMAT solutions"

5.2.2 Method

The results of the factor study (described in Chapter 4) have been used as input for the development of a process model and requirement models to describe and study relevant factors for the possible uses of IMAT solutions in the RNLAF. For all ETO factors a certain level of importance (high, medium or low) was defined, as well as a redefinition for each of them as system or environment entity. Then, the factors were used to develop a process model to see how the ETO factors and their relationships influenced the primary process of technical training with use of IMAT tools in the RNLAF.

5.3 The process model

This section describes briefly the development and outcome of the final process model for the technical training process in the RNLAF with IMAT solutions. See for a detailed description of the model development: Jacobs, van der Hulst, Verstegen & Janssen (2003).

5.3.1 Process model development

The process model was developed according to a systems approach, and followed these steps:

- First, a process model of the technical training process with use of IMAT solutions (the system) was developed without interaction with its environment, or in other words as if there were no other factors influencing or interacting with this training system. In this model a set of system entities was determined and some ETO factors, such as aircraft maintenance and aircraft availability, were placed as system entities in this model.
- Second, a process model with environment entities and environment interaction was developed. Initially, all remaining ETO factors were placed in this model as environment entities.
- Third, the process model was finalised by determining relationships between the system entities as well as between the system and environment entities. During this part of the model development new entities (factors) were also found. By using decomposition rules some of the system and environment entities (ETO factors) were eliminated from the final process model to obtain a process model focusing on the primary technical training process with use of IMAT tools in the RNLAF.

5.3.2 The final process model

The final model, of the technical training process in the RNLAF with use of the IMAT tools, is presented in the next figure.

The symbols, colours and boxes in the model have the following meaning:

- Black lined boxes represent the main *processes* in the system as black boxes.
- The *inputs* and *outputs* for a main process are depicted by blue texts.
- A new and *additional input* is also depicted as blue text, accompanied by a blue input arrow. A new input is only specified, in the model, the first time this is required in the process.
- The black arrows between the main processes in the system depict the workflow and possible directions of this workflow in the system.
- Attributes of processes or products are only specified if they are derived from the study of ETO factors, e.g. *Technical Training Characteristics* and are presented in a box with a coloured line connected to a process/ product with a black dotted line (without arrows)
- Yellow boxes depict *educational entities*, and their *influence* on the technical training process.
- Red boxes depict *technology entities*, and their *influence* on the technical training process.
- All the grey boxes depict *organisational entities*, and their *influence* on the technical training process.
- A coloured arrow between system and environment entities depicts an *influence*. E.g. the environment entity personnel availability *influences* the system aircraft maintenance and technical training.
- Between the two horizontally placed intersection lines, the IMAT workflow in the technical training process is depicted. It represents the working of the IMAT tools *as* developed in the European IMAT project.

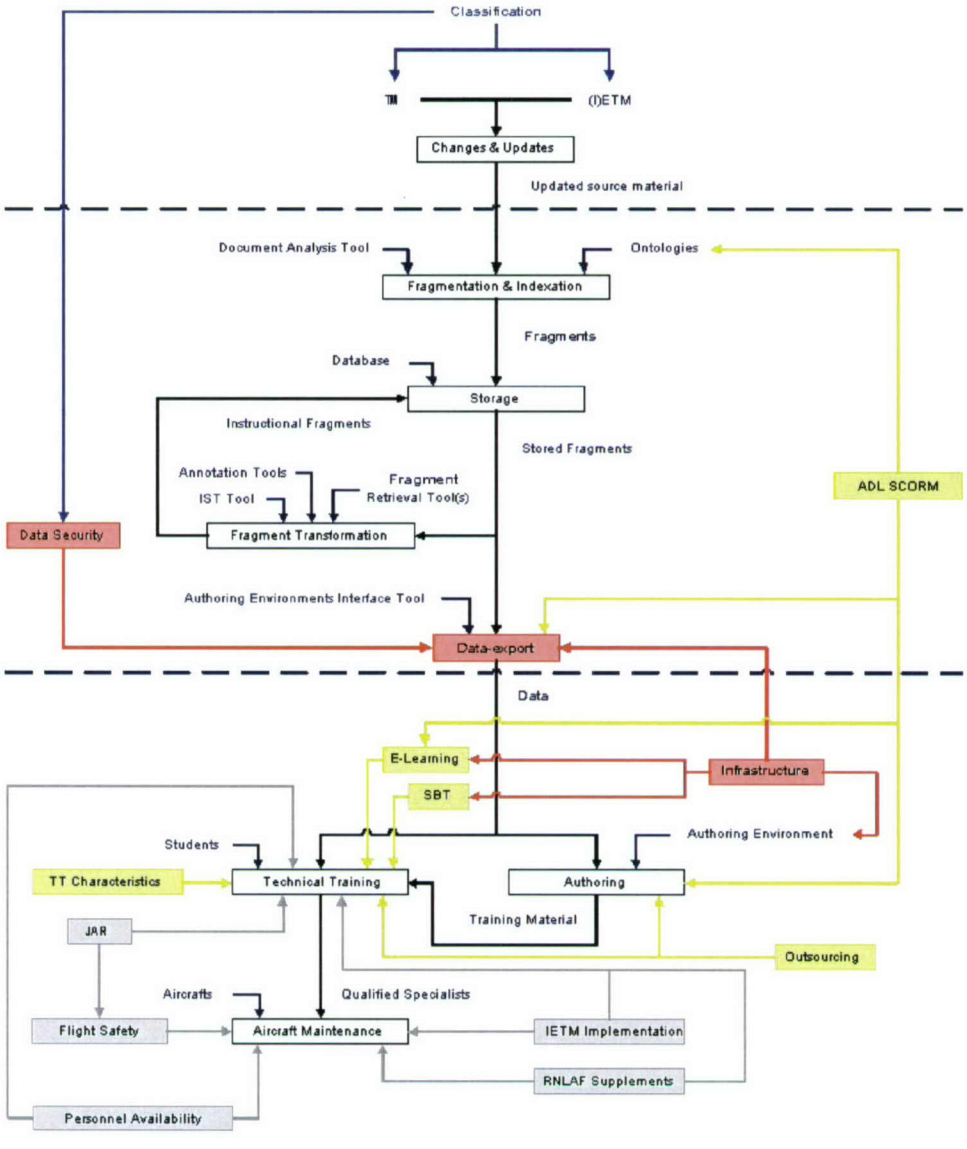

Figure 5.1: Final model of the technical training process in the RNLAF with use of the IMAT tools.

What is interesting is that organisational entities (derived from the organisational factors) mainly influence the process of aircraft maintenance and to a lesser extent the technical training process. Educational entities mainly influence the technical training and authoring process, and technical entities mainly influence the processes in the IMAT workflow. Important entities are those affecting the primary process of developing training material with IMAT tools, such as ADL-SCORM, Data-Security and Classification. Other important entities are the ones which affect both training and maintenance, such as the IETM implementation. Finally, those entities that affect both processes of technical training and authoring, such as e-learning and simulation-based training, are very important, since they influence and relate with many other factors at the centre of the technical training development and technical training process.

However, to be able to give a more detailed advice on the possible use of IMAT solutions in the RNLAF it is necessary to study further on the requirements that can be defined to be able to work with IMAT, such as reusability and reliability, in the RNLAF. Therefore, requirement models were developed. They are described in the next sections.

5.4 Requirement Model Development

To answer the question which requirements IMAT needs to fulfil to be able to work with IMAT in the RNLAF, and which requirements the RNLAF needs to fulfil, requirement models could be defined as follows:

- Given a certain ETO entity:
  - Describe the general (functional) requirement for this entity;
  - Describe the requirements IMAT needs to fulfil to be able to work with IMAT solutions; and finally
  - Describe the requirements the RNLAF needs to fulfil to be able to implement IMAT in the RNLAF.

5.4.1 Requirement Model Construction

The next steps were followed for the development of requirement models:

- Assemble important entities;
- Determine the general functional requirement for these entities;
- Determine relationships between entities and requirements in the aspect-systems;
- Develop requirement models for various aspect systems.

The selection of ETO entities for the development of requirement models was based upon the assessed level of importance. All ETO entities with relevance "high" were used. General functional requirements were then assembled and requirement models were developed. It was interesting to discover that some of the general requirements (e.g. an automatic changes and update process in IMAT) had multiple occurrences in different requirement models. Only requirement models for ETO entities resulting in new or unique requirements are thus presented in the next section.

The requirement models presented in the next section, are:

- Technical Training Characteristics Requirements Model
- Simulation Based Training Requirements Model
- E-learning Requirements Model
- Infrastructure Requirements Model
- Aviation Organisation Requirements Model
- IETM Implementation Requirements Model
- Personnel Availability Requirements Model

5.4.2 Requirement Models

The next figure gives an overview of the requirement model for technical training and technical training characteristics. The model gives an overview of the functional requirements related to these educational entities. Based upon the functional requirements, requirements for IMAT and the RNLAF can be determined. The legend placed below this model can also be used for the understanding of the other requirement models.

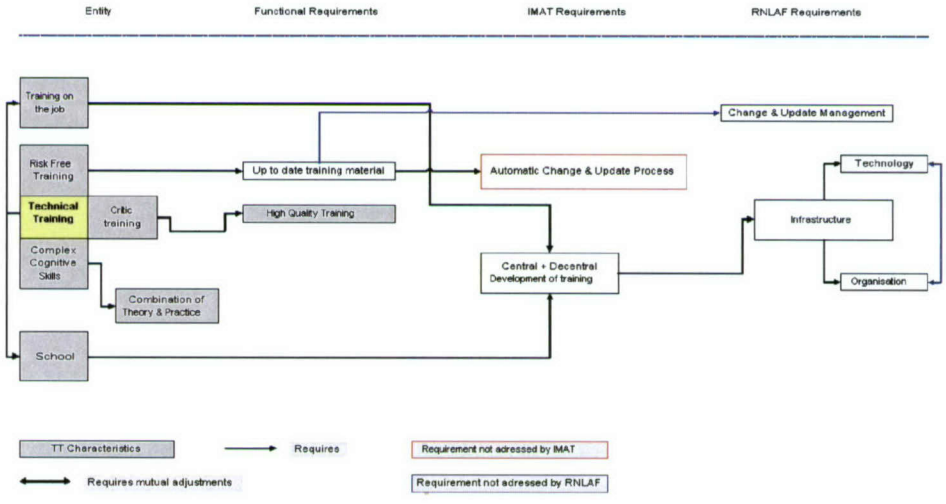

Figure 5.2: Technical Training Requirements Model

Up to date training material and high quality of training are the main functional requirements for technical training in the RNLAF. For IMAT, this results in the requirement to facilitate an automatic change and update for fragments and instructional fragments. Due to the fact that the current versions of IMAT tools do not facilitate this process the IMAT requirement is coloured red to indicate that this is a requirement that should be addressed in an IMAT solution of the future. The blue lines between technology and organisation indicate that mutual adjustments are necessary when using IMAT solutions in network-centric training solutions.

The next figure gives an overview of the requirement model for the educational entity: Simulation-Based Training.

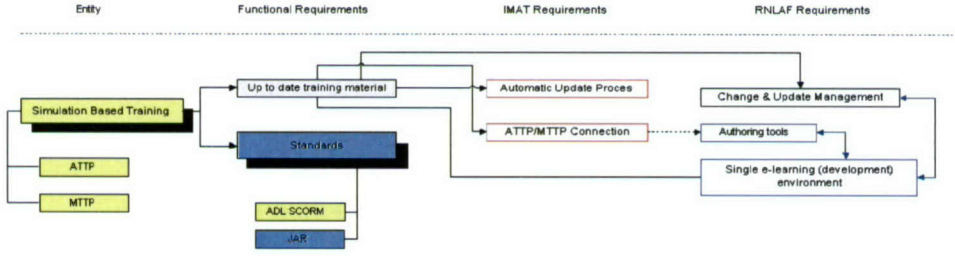

Figure 5.3: Simulation-Based Training Requirements Model

The main functional requirements for Simulation-Based Training (SBT), in the context of technical training, can be described as up to date training material and compliancy with standards. For electronic (training) content the most important standard is ADL-SCORM. For aviation-based technical training the most important standards are JAR & LE. ATTP and MTTP are important examples of SBT used by the RNLAF for training of technical specialists. For SBT keeping training up to date is a challenge (see also chapter 3). Most important IMAT requirements are an automatic update process and a connection with the authoring environment of simulation-based training environments. For the RNLAF, the most important requirements are to define which authoring tools should be selected to develop a single and integrated e-learning development and/ or authoring environment. Also, it is important to define how the organisational process of change and update management (version management, revision cycles and verification with suppliers of technical data and systems, etc.) should be designed to support the operational chain of changes and updates in an effective and efficient manner.

The next figure gives an overview of the requirement model for the educational entity e- learning.

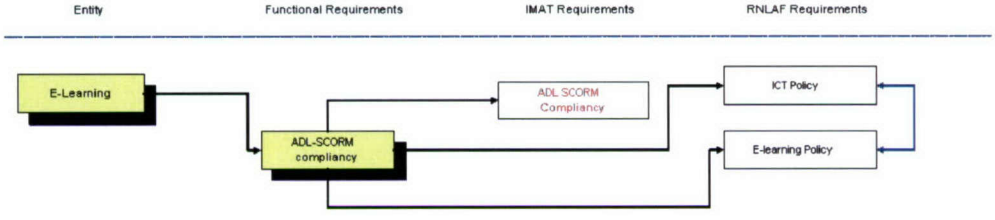

Figure 5.4: E-Learning Requirement Model

In the area of e-learning ADL SCORM compliancy is the main functional requirement, resulting in a similar requirement for IMAT. The blue lines between ICT Policy and E-Learning indicate that mutual adjustments between these two entities are necessary to be able to implement e-learning solutions successfully. Although the RNLAF is active in both fields separately, mutual adjustments to these two policies are necessary and desirable (see for instance chapter 3 on simulation-based training).

The next figure gives an overview of the requirement model for the organisational entity: aviation organisation.

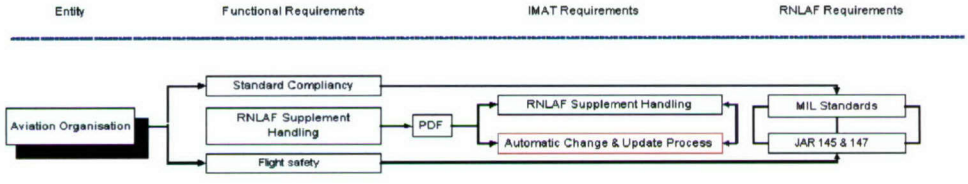

Figure 5.5: Aviation Organisation Requirements Model

For the RNLAF as aviation organisation JAR & LE Compliancy and Flight Safety are the most important main functional requirements. Due to extensive use of country –specific data, RNLAF supplement handling (in an efficient and effective manner) is the third functional requirement. This results in the IMAT requirements of RNLAF supplement handling and also an automatic change and update process, since the most important specification derived from the JAR/ LE standard is the requirement to conduct maintenance and training with up to date source material. Currently, the RNLAF creates RNLAF supplements in PDF format. This format can be used by the IMAT Pfinal set of tools as input for source material. For the RNLAF as organisation, civil and military aviation standards (JAR & LE) are the main organisational requirements.

The next figure gives an overview of the requirement model for the organisational entity Personnel Availability.

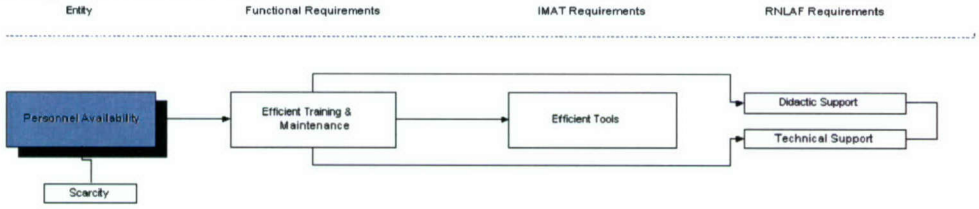

Figure 5.6: Requirements Model for Personnel Availability

Due to a scarcity in personnel in the technical maintenance and training field in the RNLAF, efficient and effective training and maintenance are a challenge. For IMAT this results in the requirement of efficient tools supporting the development of technical training in an efficient and effective manner. For the RNLAF, the main requirements are, especially in situations when personnel availability is scarce, to provide instructors, instructional developers and specialists who need training sufficient technical and didactic support either to develop, give or follow training.

The next figure gives an overview of the requirement model for the technical entity: Infrastructure.

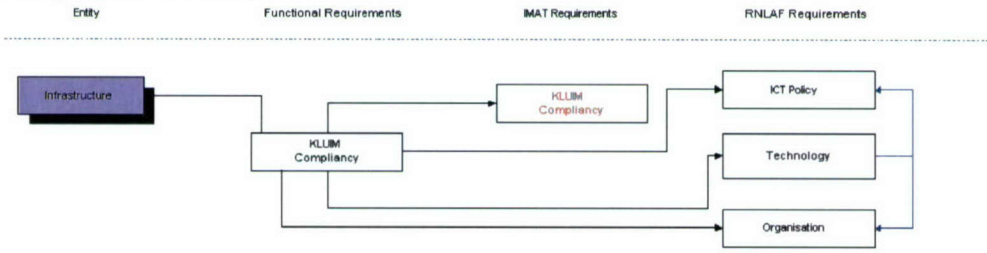

Figure 5.7: Infrastructure Requirements Model

For the technical entity Infrastructure, the main functional requirement can be formulated as "KLUIM Compliancy". This means that new technology solutions such as IMAT should be able to fulfil the demands made by this confidential network. On the other hand the RNLAF should carefully determine and adjust its

ICT policy, technology and organisation to enable the efficient and effective use of advanced training solutions.

The next figure gives an overview of the requirement model for the organisational entity: (I)ETM implementation.

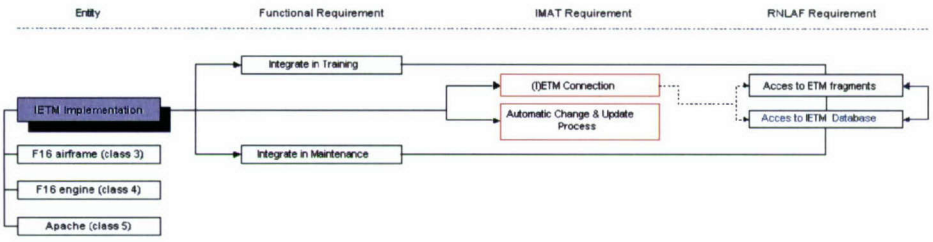

Figure 5.8: IETM Implementation Requirements Model

The main functional requirements that can be derived from the (I)ETM implementation in the RNLAF are integration in training on one hand and integration in maintenance on the other. For IMAT this results in the requirements (I)ETM connection and an automatic change and update process (due to changes and updates in (I)ETMs). For the RNLAF the main requirements are *access to* ETM fragments and *access to* the (I)ETM database. The last two requirements are crucial, in case the RNLAF wants to create training material based upon (I)ETM source material. At this moment, the RNLAF holds no access to the source material outside the presentation modules provided by the suppliers.

5.4.3 Requirements Summary

The requirement models have resulted in the next requirements for IMAT:

1. *Automatic change and update process:* this functional requirement was presented 5 times as requirement for IMAT in various requirement models.
2. *A connection with (SBT and e-learning) authoring environments:* this requirement is not only a requirement for IMAT but also for the RNLAF, implying an organisational choice (see also the next list of requirements for the RNLAF).
3. *ADL SCORM Compliancy:* through the development of a SCORM XML module in IMAT, IMAT content can be delivered in an ADL SCORM compliant manner.
4. *(I)ETM connection:* access to (I)ETM content is essential, and implies that IMAT should be able to handle or deliver content in data formats compliant with (I)ETM data formats.
5. *RNLAF supplement handling*: in case technical training should also include RNLAF supplements, IMAT should be able to handle the data formats of RNLAF supplements. This is the case at this moment (IMAT can handle PDF documents).

6. *KLUIM Compliancy:* IMAT should fit into the RNLAF ICT policy and infrastructure (KLUIM) to be able to implement and use IMAT solutions in the RNLAF.

The requirements 1 and 3 directly result in changes or adjustments of the IMAT concept. Requirement 2, 4 and 5 could result in changes in the concept of IMAT tools depending on necessary data-formats. Requirement 6 can be seen both as IMAT requirement and organisational requirement for the RNLAF.

The requirement models have resulted in the next requirements for the RNLAF:

1. *Change & Update Management:* by this is meant that the RNLAF needs to assist and set up a change and update management system from an organisational point of view similar to the current (I)ETM change and update process, enabling efficient and effective distribution of source and training material.
2. *Integrated ICT Policy and E-learning Policy:* although the RNLAF works actively on both policies separately, it will become very important to adjust and mutually adapt these two policies to create a technical and organisational sound solution for advanced training solutions now and in the nearby future.
3. *Integrated ICT Policy, Technology and Organisation:* by centralising those parts of the organisation responsible for ICT policy and technology choices, (standardisation, tools, databases, etc) demands on this matter for IMAT solutions can be set in a clear manner, consistent with current and future ICT developments in the RNLAF.
4. *JAR & LE Compliancy:* this requirement will become increasingly important for the RNLAF as aviation organisation. However, it is good to realise that the RNLAF holds an authorising position in this standardisation community, enabling the definition of an own set of standards.
5. *Access to (I)ETM content:* currently the RNLAF has no proper access to (I)ETM data in the databases. However, full access to (I)ETM data is crucial, in case the RNLAF wants to develop up-to date training material for technical training.
6. *Provide didactic & technical support for instructional developers*: a certain amount of training development will always have to be done within the RNLAF. Didactic and technical support for instructors is very important to enhance the quality and standardisation of training material.

5.5 Model Validation

Model validation can be done for different reasons or in other words answer different criteria. Examples of criteria for which model validation can be set up, are:

- Model results: is model construction useful? Does a model generate the results as anticipated?

- Model usefulness and usability: is the model valid with respect to usefulness and usability?
- Plausibility: is a model plausible in the way it explains relationships and/or the model behaviour?
- *Model completeness*: is a model complete? Are all entities present in a model? Is the behaviour of all entities in a model sufficiently explained? What is the relative importance of entities in a model?
- Model relevance: is a model relevant for the type of research?
- *Model correctness*: is a model correct? This means, are all type of entities and relationships in a model correctly described?
- Transparency: is a model transparent (or easily readable?)
- Model reliability: Is a model reliable?
- *Model construction*: is a model valid from a construction point of view?

Due to the fact that models are used in this research as method to obtain an answer on the possible use of IMAT solutions related to important ETO factors in the RNLAF, model validation has been set up to with a strong focus on *model completeness* (are factors missing?). For this purpose two expert interviews were conducted (to validate the process models) and an IMAT workshop (to validate mainly the requirement models).

Model correctness and *model construction* are two important criteria from a construction point of view and have also been selected as validation criteria. For this type of model validation two TNO-experts on model construction have been consulted.

5.5.1 Expert Interviews

This section gives a summary of the main results from two interviews conducted with RNLAF experts. Both experts were interviewed because of their broad and in-depth knowledge of the RNLAF, especially in the field of training and education, and technology-based training solutions. Both experts also had substantial knowledge of IMAT and the IMAT project.

Purpose
The general purpose of the interviews was determining whether certain factors were missing in the factor study and models, and determining the usefulness and relative importance of factors for model construction.

Method
Given the purpose of model validation by the interviewee's expertise, it is very important to give an interviewee the opportunity to generate freely own ideas and expertise on relevant factors without presenting the factors and models as described in the previous sections. To support and guide this process a questionnaire with open questions and a checklist with factors have been developed. The checklist was

used to mark factors mentioned by the interviewee and to fill in new factors mentioned by the interviewee. The questionnaire was used to ask a certain question in case an interviewee stopped generating ideas, or if the opposite was the case and remained focused on a single topic. See also: Appendix B.

Results

The most important conclusions from the interviews are presented here. They concern interviewees' agreement/disagreement with certain factors in the factor study and models as well as new factors mentioned. See for a more elaborate description of the interview results: Appendix B.

In general, the interviewees mentioned a large number of relevant factors concerning the use of IMAT in the RNLAF similar to the factors described in chapter 3. Both interviewees also mentioned several new and interesting factors. They are listed in the next table.

Table 5.1: New factors mentioned in interviews

Interview 1	**Interview 2**
1.1 Effort: What does it take to develop training material from technical manuals, with the use of IMAT?	2.1 Effort: What does it take to develop training material from technical manuals, with the use of IMAT?
1.2 Costs: both time and money.	2.2 Costs: both time and money.
1.3 Efficiency: how efficient is working with an IMAT solution?	2.3 Efficiency: how efficient is working with an IMAT solution?
-	2.4 Organisation culture: is an important factor
-	2.5 New developments in Technical Training: - Technical training redevelopment - Competency based training - Use of 4CID model
1.6 Implementation plan: get commitment for IMAT, think about change and innovation management.	2.6 Didactic support during development (e.g. SCO-Generator)
1.7 Purple policy[16]: affecting training and education.	2.7 TT design (including didactic support)
1.8 Reduction of personnel: due to budget cuts.	2.8 Reduction of personnel.
1.9 ICT Policy: IMAT should be compliant with RNLAF ICT policy and standards (database management, formats, standards, etc)	2.9 ICT organisation, laws and rules concerning KLUIM hold strong restrictions for the implementation of e- learning and IMAT solutions.

16 Purple Policy: The Netherlands Armed Forces are centralising parts of their organisations into joint (staff) organisations, e.g. the central distribution of personal gears and a central staff for training and education policy. This is referred to as "purple policy". The purpose of this re-organisation is to enhance efficiency and effectiveness in the Netherlands Armed Forces.

Conclusions
Ad 1.1-1.3 & 2.1- 2.3: Effort, costs and efficiency are three factors that should be studied carefully to enable the RNLAF to make a well-defined choice whether to use IMAT solutions or not. Although the IMAT follow-up research is aimed at defining an answer to the possible use of IMAT solutions in the RNLAF, it is not aimed at specifying e.g. a return on investment for IMAT tools, or investigating the financial consequences of development/ procurement and use of IMAT tools. This will, however, become an important factor in case the RNLAF decides to investigate the possible use of IMAT tools in the RNLAF further, and should be a topic for future research.
*Ad 2.4 and 1.7:*Although organisation culture and purple policy are important factors to take into account; their relation with the possible use of IMAT solutions in the technical training process is rather indirect or general and should not be included in the process models.
Ad 2.5, 2.6 and 2.7 New developments in TT, didactic support and TT design are important factors already (partly) addressed in the process models, but will be studied further to see whether new requirements for IMAT solutions and the RNLAF can be formulated.
*Ad 2.5:*Due to the implementation of the 4CID model in technical training (e.g. the ATTP) in the RNLAF it is interesting to find out in what way the instructional scenarios tool offers didactic support that matches or differs from the 4CID Model.
Ad1.6: It is important to develop an implementation plan and think about change and innovation management. However, this factor will become an important issue when the RNLAF decides to implement IMAT tools, and as such would be an important requirement for the RNLAF to take into account.
Ad1.8: Although this factor (reduction of personnel) was identified in chapter 3, it was interesting to see that both interviewees foresaw a scarcity of personnel in the nearby future due to budget cuts.
Ad 1.9 and 2.9: ICT organisation and ICT Policy are important factors that also have been described as requirements in the infrastructure requirement model and e-learning requirement model.

New factors that came up during the interviews were placed in a process model as presented in figure 4.3. The kind of relationships between the new entities, their relevance, and level of aggregation were determined. Additional requirement models were developed for those entities resulting in new requirements for IMAT and the RNLAF.

TT Design is an example of a new factor for which a requirement model is developed, which resulted in additional requirements for IMAT. The next figure gives an overview of a requirement model for the educational entity TT design.

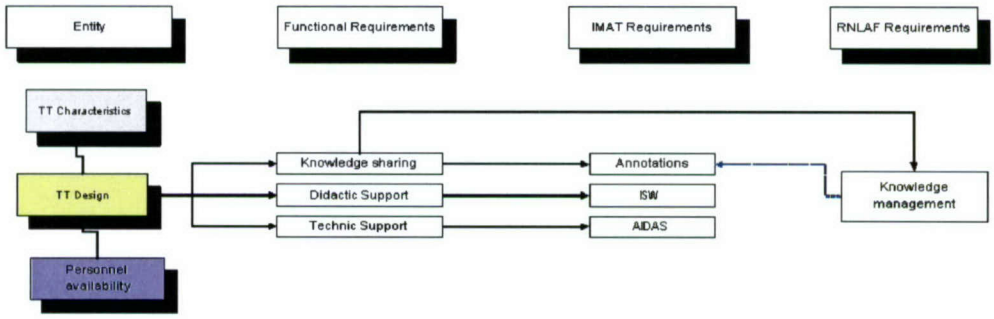

Figure 5.9: Technical Training Design Requirements Model

For TT design the main functional requirements can be described as providing didactic and technical support and knowledge. For IMAT this results in requirements for tools that facilitate organisational memory e.g. in the form of annotations (as present in the IMAT Pfinal tools). For the RNLAF the main requirement is to support and develop knowledge management. This is very important for an organisation as the RNLAF because of the high level of job rotations. IMAT tools can assist knowledge management in a practical and concrete way.

5.6 Summary

This chapter has resulted in a clear overview of how the collected ETO factors influence the possible use of IMAT solutions in the technical training process of the RNLAF through the development of a process model and various requirement models. IMAT and RNLAF requirements were set up. These will be validated in scenario assignments in an IMAT workshop. See for more information on this topic, the second IMAT report, IMAT Follow-up Research Part II (Janssen, et. al. 2004).

6. Conclusions & Recommendations

The RNLAF is a relatively small defence organisation with a broad mission. It is an organisation that possesses a wide range of (weapon) systems and related technical functions; all operated with relatively few personnel. Efficient and cost-effective use of personnel, training and equipment is therefore crucial. In this context an IMAT approach for the efficient reuse of the content of technical manuals for training purposes offers many benefits. At this moment the tools are still prototype tools and suffer from problems which make them unsuitable for direct implementation in the RNLAF organisation.

Technical manuals will, in the future, be delivered in some electronic format. Just as now, the content of technical manuals will be the basis for instructional material. This will even be required by JAR standards. So the RNLAF needs to think about effective and efficient ways to reuse material from technical manuals for training purposes, and address issues such as:

- establishing search mechanisms to find appropriate material in the technical manuals;
- ensuring full access to source materials;
- keeping instructional material up-to-date and in accordance with updates of the technical manuals; and
- sharing knowledge about source and instructional material between instructors, but also between instructors and developers within and outside the RNLAF.

The IMAT approach offers a solution to these problems by using ontologies to index source material (from the technical and didactic viewpoints) and annotation mechanisms to support knowledge management. The results of the IMAT follow-up research show that for complete implementation of the IMAT approach investments would be required that to be worthwhile for the RNLAF will depend, amongst other things, on the choice the RNLAF makes regarding outsourcing of training development and training.

In this chapter we first describe the requirements that would have to be met for a successful implementation of the IMAT approach in the RNLAF. In the last section we conclude with recommendations for an IMAT roadmap.

6.1 Requirements for the implementation of the IMAT approach

We have differentiated between requirements for the IMAT tools and requirements for the RNLAF organisation. The requirements are derived from the work as described in the IMAT Follow-up Research Reports, Part I and II.

6.1.1 Requirements for the IMAT tools

The goal of the European research project IMAT was to construct a set of prototypes sufficiently developed and evaluated to start the construction of commercially exploitable tools. As a consequence the current tools need to be further developed. Below we list requirements that are currently not met, starting with the most important ones:

- *Implementation of an automatic change & update mechanism for the IMAT database*
  This should enable the reusability of previously indexed fragments after an update of the source material. In addition to the version management facilities in the IMAT Pfinal tools, change and update notifications and "fragment or text comparison" should become part of future IMAT tools.

- *Implementation of an (semi-)automatic change & update mechanism for the instructional material*
  Facilities to keep instructional material accurate and up to date are a requirement for the successful application of the IMAT approach within the RNLAF. This requires further development of two aspects not currently addressed in the prototype tools:
  - an update mechanism to update the IMAT database without losing added information, such as meta-data and annotations, and
  - a mechanism to keep instructional material in accordance with the updated database.

  Regarding the second aspect, several solutions seem possible. One would be to set up a direct link between the tools that are used to present instructional material and the IMAT database. In this case, each time that the instructional material is presented, the required fragments are retrieved in real time from the (up-to-date) IMAT database. Another solution would be to integrate an authoring tool within the IMAT tool set. In this case a dedicated interface can be constructed to allow update of source material to propagate automatically to the instructional material, or to provide notifications at locations in the lesson material where a modified fragment is used (so that the developer will then be able to make the required changes e.g. by clicking a hyperlink to the source material). From an organisational point of view this requires that the RNLAF will have to select a single or very limited number of authoring and e-learning platforms.

- *Ensuring JAR compliance*
  Important implications of this standard concern the way training, assessment and aviation maintenance should be set up by the RNLAF. Most important JAR implication for the IMAT tools at present is the prerequisite to conduct aviation training and maintenance with up to date source material (see above).

- *Exchangeability with other tools/ systems*
  The current prototypes are based on input in the form of PDF documents. However, in the future the RNLAF will use different types of (I)ETMs, and those provide the input for the IMAT tools. Adaptation of the IMAT tools to HTML and XML input should not be difficult, as these formats are already used during the analysis process (and in fact proved to be possible with expert help during the European IMAT project). The IMAT tools also need to communicate with or be integrated with the authoring systems and LMS that the RNLAF chooses to use.

- *Ensuring ADL-SCORM compliance and interaction with the SCO generator*
  This requires an adjustment in the IMAT concept. Basically a number of incompatibilities with respect to the way stored materials are structured and how they are labeled by means of meta-data need to be overcome. The easiest and cheapest solution is to concentrate only on a lower level connection between IMAT and the SCO generator. This solution is based upon the application of IMAT fragments as SCORM Assets. The only conversion that needs to take place is from IMAT meta-data to SCORM meta-data, which can be performed manually in the SCO generator in the meta-data editor. The more complex and expensive solution is to provide also a higher level connection. This solution is based upon the application of IMAT fragments as SCOs. An extra IMAT module should be created to convert the structure of the IMAT fragments into the SCORM structure of SCOs, and if desired, also to convert (partly automatically) IMAT meta-data to SCORM meta-data. The data model of SCORM, however, is not able to facilitate in the didactical richness of the IMAT meta-data. It is suggested to use the technique of profiling, in order to mediate between the two data models (See Veerman, et. al., 2002).

- *Improve reliability of the tools*
  The prototype tools still have a number of problems. This is most clear in the most complex tool: the document analysis tool. When we tried to fragment and index the new input document we discovered, for example, that some parts of the document were not indexed and that the number of fragments sometimes varied on different computers. Similar problems were also reported in usability studies during the European IMAT project. The tools must support the fragmentation and retrieval of fragments in a reliable manner. In this, one should focus particularly on the database and document analysis tool, especially given the large amounts of data in technical domains.

- *Improving the usability of the IMAT tools:*
  The perceived complexity of the tools is higher than necessary. This seems to be due tot the fact that the IMAT concept is always explained in relation to the ontologies that underlie it. For non-expert users this is not necessary. Furthermore, using the IMAT tools should be made more intuitive.

  Based on the requirements as described above, the next figure presents an overview of an IMAT concept for the future. The transparent boxes in this

model represent processes, as a black box. The blue texts represent the necessary in- and outputs. A new input is only specified the first time this is required in the process. Between the two dotted horizontal lines, the IMAT process flow is depicted. One of the lines is coloured red to indicate that this *future* IMAT solution is an extension of the IMAT concept as defined in the European IMAT project. Also, the red texts mark inputs or processes that are new compared to the IMAT concept as developed in the European IMAT project.

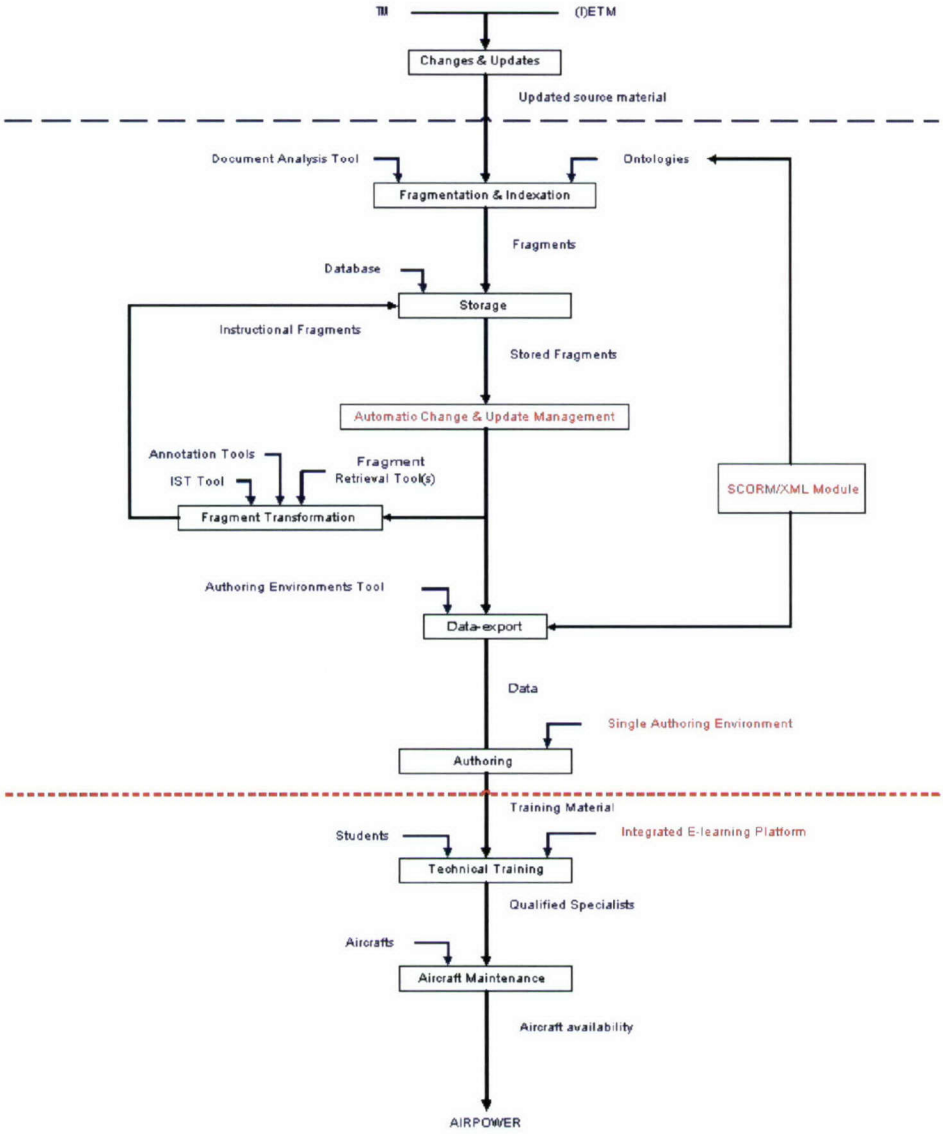

Figure 6.1: Model of a future IMAT solution embedded in the technical training process of the RNLAF.

6.1.2 Requirements for the RNLAF Organisation

The successful implementation of the IMAT approach also requires changes in the RNLAF organisation. These are listed below:

- *Implementation of a change & update management process for IMAT.*
  The RNLAF needs to assist and set up a change and update management process that enables efficient and effective distribution of source material (technical manuals), IMAT databases with indexed fragments and training material, similar to the current change and update management of technical manuals and (I)ETMs.

- *Integration with IETM implementation.*
  It is very important for the RNLAF to anticipate on the arrival of (I)ETMs in their organisation and to define exactly what kind of maintenance and training solution they will (and will have to) provide for the RNLAF organisation. If an IMAT approach is applied then it should be possible to use the (I)ETM material as input for the IMAT tools. This implies that the RNLAF should have substantial knowledge on IMAT solutions, IETMs, and developments in this area. Establishing a contract relationship with IETM suppliers or setting up joint partnerships with other countries and organisations using the same systems will make it possible to have a say in in the specification, development and delivery of (I)ETMs.

- *Ensuring access to electronic content.*
  A more specific aspect is the access to electronic content: e.g. IETM databases or databases of advanced training solutions provided by external suppliers. At this moment it is probable that the RNLAF will in many cases not have access to source material, e.g. in (I)ETMs. This makes the reuse of source material extremely difficult: not only in the IMAT approach, but also in other advanced training solutions such as the ATTP.

- *Standardisation of electronic content.*
  This is an important means to gain real exchangeability, reusability and easier access to electronic content. See also the IMAT requirements described in the previous section.

- *Ensuring an integration of ICT- and E-learning policy.*
  Mutual adjustments between these two policies are necessary to enable successfully large-scale implementations of advanced training solution today and in the (nearby) future. These policies also need to be aligned and further developed in order to decide if and how the IMAT approach is going to be applied. They also determine RNLAF demands for IMAT tools.

- *Provide didactic & technical support to instructional developers.*
  It is likely that a certain amount of training development will always have to be done within the RNLAF. Didactic and technical support for training developers is important to enhance the quality and standardisation of training material. An example of how such support can be set up is the Instructional Scenarios Tool in IMAT.

- *Focus on modular competence-based training*
  IMAT can serve the development of different kinds of instructional material in different ways. It may be used for a centralised development of very basic instructional material, but it may also serve to support training on the job where technicians can prepare themselves 'just-in-time' for a complex or highly specialised task. IMAT will then help to find the right material rather than serve as a set of tools for the construction of instructional material.

6.2 Recommendations

Based upon the requirements as described in the previous sections, the next IMAT roadmap can be defined for the RNLAF in case the RNLAF decides to develop and implement an operational set of IMAT tools:

- Make IMAT solutions and knowledge known to other parts in the RNALF and/or other parts of the Netherlands Armed Forces.
- Use the lessons learned in the IMAT project and IMAT follow up research to set up the specifications for an operational set of IMAT tools.
- Define how an IMAT solution should fit into the ICT policy, e-learning policy and ICT standards adapted by the RNLAF.
- Adjust ICT policy and educational policy to be able to benefit fully from advanced training solutions such as the IMAT approach.
- Select an authoring environment or e-learning platform to create a closed training (development) environment in which a change and update mechanism can be provided using an IMAT approach.
- Set up an implementation plan (with a focus on change and innovation management) for those parts of the RNLAF organisation, which are going to work with IMAT tools.
- Verify how the purple policy affects or can be used for the implementation of the IMAT approach in the RNLAF. This can be done together with other partners in the Netherlands Armed Forces such as the Royal Netherlands Navy, which holds substantial knowledge of e.g. (I)ETMs.

Even when the IMAT tools are not further developed, the RNLAF can make use of concepts that were developed within the IMAT projects and the lessons learned. The Instructional Scenarios Tool (for the construction of instructional scenarios), for example, can also be used outside the IMAT context. The ontologies and annotation framework can be used in other tools, and they can serve as an inspiration for demands or expectations from IETM facilities. Experience with the IMAT approach and prototype tools can serve as a stimulus to think about different ways of organising the development and use of instructional material. If further

development of the prototype tools will take place, the three IMAT follow-up Research Reports (Part I, II and the report on an ADL SCORM Compliant IMAT System) should form the basis for a needs statement.

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8. Signature

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Appendix A Interview Reports

A.1 Interview method

Purpose

- Validation of factor model
- Discover and discuss important and relevant developments concerning the use of IMAT solutions in the RNLAF
- Add missing factors to the model
- Delete "false" factors from the model

Introduction

TNO is currently seeking to define a set of relevant factors concerning the use of IMAT solutions in the RNLAF. The purpose of this 'factor analysis' is the definition of relevant factors in the RNLAF resulting in a factor model. This model can guide the development of relevant scenarios concerning the various use of IMAT solutions in the RNLAF. Interviews will take place with senior specialists with broad knowledge of the RNLAF, especially in the field of (technical) training and education and preferably knowledge of IMAT solutions. If the latter knowledge is not present, a presentation of IMAT prior to the interview can solve this issue. The purpose of the interviews is validation of the factor model, which has been designed as a result of desktop research including a literature study, project members' knowledge of the RNLAF and their TNO projects for the RNLAF in the field of training and education (including IMAT, IETM, COOL and MTTP).

IMAT is a technology-based training (development) solution. When considering the use of such a solution it is useful for an organisation to look at this from various angles. This project proposes an educational, technical and organisational approach and all interviewee should think about and describe all the relevant factors for the possible use of IMAT solutions in the future for the RNLAF from these three angles of approach.

Method

As mentioned the purpose of the interview is validation of the factor model by the interviewee's expertise. It is therefore important to give interviewees the opportunity to generate and present their own ideas and expertise freely on relevant factors without presenting factors or the factor model to them. To support and guide this process a checklist of questions and factors has been developed which can be used as checklist (and can be marked when an interviewee mentions a certain factor or answers a certain question). Or can be used to ask a certain question in case an interviewee stops generating ideas, or if the opposite is the case, focuses on a single topic.

A.2 Questionnaire

Algemene opmerkingen:
- Vragen beperken zich tot de scope van de KLu.
- Met IMAT bedoelen we IMAT concept.

Algemene vragen
1. Wat speelt er bij de Klu op het gebied van TT?
   - Noem de drie belangrijkste ontwikkelingen?
   - Wat zijn de belangrijkste uitdagingen en knelpunten?
2. Wat moet er veranderen aan IMAT om IMAT binnen de Klu inzetbaar te maken?
3. Wat moet er in de organisatie gebeuren om met IMAT te kunnen werken?

Educatieve vragen
Welke educatieve factoren zijn van belang bij het inzetten van ondersteunende tools bij het omzetten van bronmateriaal uit technische handleidingen in instructie materiaal (zoals IMAT)?

Algemeen
1. Wat is de omvang en het belang van technische opleidingen in de KLu?
2. Wat zijn typische kenmerken en uitdagingen van TT?
3. Is er naar verwachting in de toekomst een grote toestroom van studenten?
4. Hoe zou u de studenten binnen de Klu typeren?
   - Wat is hun achtergrond en ervaring?
   - Heersen er grote verschillen in bekwaamheden?
5. Hoe zou u de instructeurs binnen de Klu typeren?
   - Wat is hun achtergrond en ervaring?
   - Heersen er grote verschillen in bekwaamheden?
6. Is er een grote diversiteit aan trainingen binnen de Klu?
   - Op wat voor vlakken?
   (Bijv. meer focus op Hands On Training, meer focus op feitenkennis, leren van complexe technische vaardigheden, procedures leren, etc.)
7. Zijn er belangrijke verschillen /overeenkomsten tussen de KLU en civiele bedrijven (bv. luchtvaartindustrie) in de wijze waarop zij TT inrichten? En andere Luchtmachten?

Ontwerp
8. Wat zijn belangrijke kenmerken van TT binnen de Klu om rekening te houden bij het ontwerpen en geven van TT?
9. Waar zitten de grootste knelpunten op het gebied van trainingsontwerp en ontwikkeling bij de Klu? +
10. Streeft de Klu naar meer generieke oplossingen? (Qua trainingsontwerp)

11. Streeft de Klu naar meer individualistische trainingsoplossingen? (adaptieve leertrajecten)
12. Wil de luchtmacht zijn specialisten de nodige vrijheid bieden in the creëren van lesmateriaal?+
    - Zo ja, op welke vlakken?
    - Welke specifieke problemen (als die er zijn) worden daarbij voorzien?
13. Is outsourcen van TT ontwikkeling een mogelijk oplossing voor efficiënte TT ontwikkeling bij de KLu? +
    - zo ja, waarom?
    - zo nee, waarom?

Geavanceerde trainingsoplossingen

14. Wat zijn de ontwikkelingen in de nabije toekomst op het gebied van e-learning?
15. Wat zijn mogelijke knelpunten hierbij?
16. In hoeverre zijn standaarden als ADL- SCORM leidend bij e-learning oplossingen?
17. Zijn er belangrijke ontwikkelingen op het gebied van simulatie gebaseerd opleiden voor TT bij de KLu?
    - Wat zijn de huidige onderkende knelpunten hierbij?
    - En in de toekomst?
18. Zijn er belangrijke lessen te leren uit het MTTP /ATTP traject aangaande de ontwikkeling van instructie materiaal voor een blended learning solution?

TT Curriculum

19. Wat zijn de belangrijkste ontwikkelingen inzake de inrichting van het TT curriculum? (training on the job, blended learning?)
20. Zou IMAT hierin een bijdrage kunnen leveren?

21. Zijn er belangrijke lessen die uit het HIVO project kunnen worden getrokken die ook kunnen gelden voor IMAT?
22. Wordt TT gecentraliseerd (eerste deel van de opleiding) bij de KMSL?
23. Hoe en waar worden de zogenaamde bedrijfsscholen voor TT ingericht?

24. Is outsourcen van TT een mogelijke oplossing voor het geven van TT bij de KLu?
25. Hoe belangrijk is het om met up to date en accuraat lesmateriaal te trainen?

Effectiviteit

26. Waar zitten de grootste knelpunten op het gebied van trainingseffectiviteit bij de Klu? (niveaus, verschillen tussen school en praktijk)

Technische Vragen
Welke belangrijke ontwikkelingen spelen er op het gebied van techniek die van belang kunnen zijn voor de toepassing van IMAT binnen de KLu? (Bijvoorbeeld: netwerk beveiliging, infrastructuur, capaciteit, etc…)

IMAT
27. Wat zijn vanuit een technisch perspectief belangrijke voorwaarden voor IMAT achtige oplossingen om te kunnen worden ingezet?
28. Is het concept om ontologieen in te zetten binnen IMAT een waardevol idee, dat wellicht ook daarbuiten zou kunnen worden toegepast?

Organisatie/ Infrastructuur
29. Zijn er belangrijke eisen die aan IMAT worden gesteld vanuit een technisch perspectief?
    - bijvoorbeeld ten aanzien van data- beveiliging
30. Is de KLu infrastructuur voldoende ingericht op nieuwe technische trainingsconcepten zoals IMAT en e-learning?
31. Hoe zou u het technology level van de KLu omschrijven?
    - op individueel niveau (computer expertise)
    - op organisatie- niveau (infrastructuur)

KLu- supplementen
32. Hoe wil de KLu in de nabije toekomst omgaan met de KLu- supplementen?
    - formaat.
    - changes & updates
33. Dient een IMAT oplossing hiermee rekening te houden? En deze te kunnen verwerken?

Domein
34. Hoe dynamisch / veranderlijk is het luchtmacht domein? Denk bij voorbeeld aan de vernieuwingen in bron materieel+
35. Zijn de domeinen die spelen binnen de Klu onderling sterk vergelijkbaar (denk aan de domein complexiteit zowel als wat er geleerd moet worden in het domein)?
36. Zijn volgens u domeinanalyses ter bevordering van de trainingen de investering waard?

Organisatiekundige vragen
Welke ontwikkelingen in de KLu organisatie hebben een belangrijke invloed op technische training en opleiding en de wijze van inrichting hiervan? +

Organisatie
37. Welke organisatiekenmerken (al dan niet typisch voor defensie) kunnen van belang zijn voor de inrichting van TT en TT- oplossingen als IMAT? +
38. Welke effecten hebben de beschikbaarheid van personeel voor T&O? +

39. Zijn er knelpunten aangaande personeel?
- Wat voor soort personeel?
  - Instructeurs
  - OTT
  - Ontwikkelaars
  - Onderhoudstechnici
40. Op wat voor manier kunnen efficiënte en effectieve training (ontwikkeling) bijdragen bij de inzet van schaarse capaciteit?
41. Welke kenmerken en uitdagingen voor de organisatie zijn van invloed op T&O en eisen die hieraan worden gesteld?
    - reorganisaties (van WOLF naar WING)
    - budget cut downs
42. Vliegtuiginzetbaarheid: Op wat voor manier kunnen innovatieve trainingsoplossingen bijdragen aan een hogere vliegtuiginzetbaarheid?

IETM

43. Welke consequenties heeft de invoering van IETMs voor TT binnen de KLu? +
44. Is het belangrijk voor de KLu om overeenkomsten en verschillen tussen IETMs en IMAT te kennen?
45. Welke zaken zijn van belang om te weten in relatie tot de ontwikkelingen binnen IMAT en IETM wereld?

Standaarden

46. In hoeverre hebben de ontwikkelingen op het gebied van standaarden in de luchtvaart invloed op vliegtuigonderhoud en training?
    - JAR 146 en JAR 147 +
47. In hoeverre hebben zaken als flight safety implicaties op de wijze waarop TT wordt ingericht?
    - JAR 146 and JAR147 implicaties? +

KLu Supplementen

48. Moet een IMAT oplossing rekening te houden met de KLu- supplementen? En deze aan kunnen?

Samenwerking en internationalisatie/ nationale aspecten

49. Wat is de visie van de Klu voor wat betreft de groeiende internationale coöperatie tussen luchtmachten en de invloed daarvan op de trainingen?
50. Spelen er locale aspecten in trainingen die in acht moeten worden genomen? Denk bijvoorbeeld aan taal, locale condities, verschillen in materieel, cultuurspecifieke verschillen in organisatie, houding, etc.?

Organisatiecultuur

51. Staat de organisatie open voor veranderingen in rollen en verantwoordelijkheden van betrokken partijen (instructeurs, specialisten op de werkvloer, etc.)?
52. Zo ja, Erkend men dat dit veel investeringen zal kosten?

Beleid

53. Hoe ziet het KLu beleid ten aanzien van TT en geavanceerde trainingsconcepten er uit?
    -Voor de komende vijf jaar?
54. En langere termijn? Biedt het beleid van de Klu voldoende speelruimte voor afstemming tussen verschillende onderdelen van de trainingen: de werkwijze, roostering, toetsing en kwaliteitszorg?

Extra Vragen

- Zijn er andere factoren die van belang zijn voor de KLu en IMAT achtige oplossingen?
- Is het belangrijk dat de KLu op de hoogte is en kennis heeft van IMAT achtige ontwikkelingen?

A.3 Interview 1

Interview results

"Concerning: relevant factors in the RNLAF for the future use of IMAT solutions"

Interviewee data
Name: Dr. Ir. Hilbert Kuiper
Function: RNLAF Program leader T&E TNO
Interviewers: Nieke Janssen (TNO HF) and Lesley Jacobs (TNO)
Location: At the interviewee's office at TNO in The Hague
Time and duration: 13.00 - 14.45
Date: 10-2-2002

The interviewee's main responsibility is to manage, co-ordinate and evaluate TNO training and education (T&E) projects for the RNLAF. This also involves the co-ordination and definition of future T&E research programmes. Hilbert Kuiper is involved in programmes in the area of e-learning, training developments, IETM research, use of e-tools on the job, IMAT, tactical training, MTDS[17], etc.

17 Mission Training (through) Distributed Simulation

General

Important issues in the area of TT in the RNLAF:
- E-learning
- blended learning (purple programme)
- training on the job (but also the issues concerning how the initial training of technicians can be improved so that students obtain the knowledge and skills to move faster and be better prepared for their tasks)

Bottlenecks in the TT developments at the RNLAF:
- The effort that it takes to make manuals suitable for training (it would be very helpful if the manufacturer provided task-oriented manuals),
- Speed of electronic communication in the past; there was often was insufficient interaction in training material (CBT, simulation, etc.),
- The infrastructure of the RNLAF (KLUIM) has many limitations,
- Currently, there is a lot of duplication between the research done at the various defence organisations (RNLAF, RN, RNA). For instance in the area of e-learning, co-ordinating research and projects on e-learning within the Netherlands Armed Forces will prevent duplication and lead to better knowledge sharing between the defence organisations (also, there is a trend foreseen in a purple training and education research programme and policy)

What is of interest in the IMAT concept:
The IMAT project is a good project from a scientific point of view and the concept is interesting. The subject 'fragmenting source material' is an important topic as the future will see many systems enhanced with electronic manuals. In practice, the instructors literally use the manuals to write their lesson material. The IMAT tools offer opportunities to support this process.

What should change on the side of IMAT to make it applicable in the RNLAF?
The tools are complex to use and knowledge on this matter within the RNLAF is restricted to GGW de PEEL (a participant in the IMAT project). It is therefore crucial to know how to translate the results of the IMAT project into practice and transfer the knowledge and lessons learned to other parts of the RNLAF organisation. The real question however is how to do this? The first step is probably to make IMAT knowledge more widely available in the RNLAF. When this is done, an important next step is to define a user case and start thinking of how such tools can be implemented in the organisation (implementation, change and innovation management)

What should change on the side of the organisation to make IMAT applicable in the RNLAF?
- A first step for a successful implementation is the prerequisite of commitment within the RNLAF to work with IMAT tools.

- IMAT provides a possible solution that affects the training development process profoundly, RNLAF T&E policy should address these matters and include implementation factors such as commitment.
- The IMAT concept should not be introduced across the organisation at once. A test case (e.g. at GGW De Peel) ideally in a new domain with no current training material, could be used as a first implementation test, to explore strengths and weaknesses, before implementing the tools on a wider scale.

Educational factors

TT Importance
Within the RNLAF TT is probably the largest part of training and is critically important.

Relevant educational factors for the applicability of IMAT:
Instructors have strong technical domain expertise and lesser didactic expertise. In practice, however, the roles of technical expert, instructor and instructional designer are integrated in the one person. So an instructor needs didactical support to transform the source material, (technical manuals) into instructional material.

Design
Relevant TT characteristics to consider in the design of TT at the RNLAF:
In TT, the design of simulations and animations is an important and difficult task. The stakeholders are keen on this and fidelity requirements (level of realism), are high.

Generic training design/adaptive solutions:
A trend at the RNLAF is towards more generic training solutions. On the other hand, there also is a trend towards more adaptive learning solutions.

Freedom for specialists in TT design:
For TT design (for which the choice is made to do in-house development within the RNLAF, e.g. CBT development or e-learning) the RNLAF would probably wish to give instructors a certain level of freedom in designing their own material. However technical specialists or experts (SME) would need to monitor the development process.

Bottlenecks in TT design and development at the RNLAF:
- A main bottleneck is high development times.
- Stakeholders in TT have very high demands on the quality of training (for example on the issue of fidelity in for example simulation-based training methods).
- The development process requires domain expertise, but the RNLAF does not have the people and expertise to do all types of training development jobs

themselves. This for example concerns didactical expertise that is required to design training solutions and skills required for simulation development.
- The airforce experienced that, with outsourcing of training development, the risk is high that they do not get what they want.

Outsourcing of TT development:
Considering the lack of expertise within the organisation, outsourcing TT development can be effective. However, it requires close involvement of the airforce to ensure that what is done is what has to be done. For example, when outsourcing development of advanced CBT, the management and feedback process should be handled by the RNLAF.

Advanced training solutions
The airforce aims to take advantage of the opportunities created by developments in the area of electronic learning (such as e-learning and blended learning). The main goal of these new training strategies is to shorten the initial training time at school. An important development in the area of e-learning is the RNLAF's adaptation of ADL-SCORM.

Reusability of material/ADL SCORM
The reusability of material is important for reasons primarily of cost-effectiveness. Co-operation between countries will also increase and require greater exchangeability of material between countries.

Important developments in the area of advanced training solutions
- An important development is JSF and the TT that will be involved, based upon class 5 IETMS with connected databases for maintenance, logistics, e-learning and EPSS kind of solutions
- MTDS is another important development concerning the connection of multiple simulator trainers for pilots (live flying with multiple pilots in connected training simulators)

Lessons learned from ATTP/MTTP:
- The ATTP product is not what the RNLAF wanted. The lesson learned is to keep in close involvement wit the developer
- Fidelity remains an important topic in simulation-based training (stakeholders want a high degree of fidelity, even when research indicates this is not necessary for a certain part (or function) of the training).

TT Curriculum

Relevant developments considering the definition of the TT curriculum:
Electronic manuals and training material developed from them allow one to use several sources of information, to provide information just in time, e.g. to look for examples in a central database (accessible via the network allowing centralised maintenance).

Centralisation of TT:
The initial part of TT will be centralised at the KMSL and the rest of the training will be given at a 'leerbedrijf' (business school).

Outsourcing of training
The new electronic means of communication will increasingly provide support for training at the workplace. Outsourcing of training will be interesting only for specific parts of the training, for instance specific parts of initial training (prepared in another country that has the same weapon system).

Up to date training material:
Up to date training material is crucial in view of the high speed of change in hardware and its related software.

Technical factors

Technical developments of relevance:
One needs a central database, accessible from multiple (view)points to support the new ways of learning such as training on the job/ just in time/ just enough, IETMs, EPSS and video conferencing. The right information needs to be available at the right time.

Technical prerequisites (requirements) to be able to work with IMAT in the RNLAF:
- Infrastructure: KLUIM currently prevents many-advanced (network) training solutions from a full-scale implementation.
- Means: as an organisation the RNLAF needs to provide users of IMAT with sufficient resources to create good instructional material (e.g. computer, authoring tools, access to central database, etc.)
- Data security: will be an issue when working with classified information in technical manuals and training (not allowed on KLUIM).

Ontology Concept:
It could be useful to consider further (besides or outside IMAT) generating metadata for electronic content.

Organisation/infrastructure

- Technical requirements for IMAT: IMAT must respond to RNLAF ICT policy and be compliant with it e.g. the choices RNLAF makes concerning database management, electronic formats and ADL SCORM. The IMAT solution must integrate in the RNLAF architecture and policy.
- Data-security is (within the RNLAF confidential network KLUIM) only an issue when classified material is used.

Technology level

The RNLAF is advanced in its use of high technology (according to the interviewee also compared to other Dutch defence organisations, e.g. ADL-SCORM). For the students this may depend on the entrance level.

RNLAF Supplements

It is important that the IMAT concept conveniently facilitates updates of RNLAF supplements.

Domain

- The RNLAF domains are dynamic, with regular updates e.g. of source material once per two months.
- The RNLAF domains are strongly similar.

Domain analysis:

- An important question is: what is the cost-benefit in time and investments to develop and maintain a domain ontology.

Organisational factors

Important characteristics and developments in the RNLAF for the use of IMAT solutions

- An important question to be addressed is how to get commitment within the RNLAF for such a training solution?
- Reusability is a main topic for the use and re-use of electronic content.
- IETM implementation.

Consequences of budget cut

- Centralisation of training
- Centralisation of policy activities
- Personnel reductions

Efficiency

For efficiency reasons reusability of material is very important.

Challenges for the organisation
- Increases emphasis on efficiency, purple policy (also within the area of training), cost reductions
- Analyse training programmes and define doubles (within RNLAF and other Dutch Defence organisations)

Increase flight hours:
New ways of training could increase returns on investment in training if it leads to more flight hours.

IETM:
- IETMs support the availability of information, probably in a more effective way
- The IETM implementation could lead to a smaller part of instructor lead training, and more self directed learning.
- For the RNLAF it is very important to understand the exact difference between IMAT and IETMs. What offers IMAT more in the area of training?

New ways of training:
A consequence of new ways of training is that the role of an instructor changes drastically

International/ local factors:
- The RNLAF increasingly works together with countries with the same weapon systems on matters as maintenance (EPAF countries) and training (MTTP/ATTP example: partnership with Norway to set up F16 maintenance training)
- For instance for the JSF, choices can be made whether the RNLAF develops its own training, buys in training, or outsources certain parts of training in other countries. In essence this is a matter of cost-analysis
- The most important local factors are training material and organisation

Organisation culture
Policymakers are progressive and open to changes in roles and responsibilities. They however realise that it will cost a lot for people in the field to change and to obtain commitment for a certain change/innovation

Policy
RNLAF policy for TT (long term):
- Just enough
- Just in time
- Blended learning
- Leerbedrijven

The interviewee will see that the interviewers get a copy of the recently written RNLAF policy paper on future training within the RNLAF.

Summary
New factors that came up in this interview:
- Effort: what does it cost to develop training material from technical manuals (with the use of IMAT)?
- Costs: both time and money.
- Efficiency: how efficient is working with an IMAT solution?
- ICT Policy: IMAT should be compliant with RNLAF ICT policy and standards(database management, formats, standards, etc)
- Reduction of personnel due to budget cuts.
- Purple policy[18] affecting training and education
- Implementation plan: get commitment, think about change and innovation management.

New questions that came up in this interview:
- What is gained by using IMAT instead of using IETMs in the area of training?
- How do you get commitment within the RNLAF for IMAT?
- How do you get the product that you want? (ATTP example but also in IMAT)

A.4 Interview 2

Interview Results

"Concerning relevant factors in the RNLAF for the future use of IMAT solutions"

Interviewee data
Interviewee: Dr. Willem Hylkema
Function: RNLAF Program leader Training & Education
Interviewers: Nieke Janssen (TNO HF) and Lesley Jacobs (TNO)
Interview setting: at the office of the interviewee in the RNLAF headquarters in The Hague
Time and duration of interview: 13.15 -15.00
Date: 11-2-2002

General
Important issues in the area of TT in the RNLAF:
- The adaptation of ADL SCORM for the standardisation of e-learning content.
- TT in the RNLAF concerns mostly the F16/Apache domain. In general the training projects focus on a *structural redevelopment* of the training. Examples

[18] Purple Policy: explanation

in the F16 domain are the ATTP and MTTP project. The Apache is a new weapon system, and training material is from the USAF.
- Development costs: how to develop good content cost–effectively?
- Quality of simulation in technical training is a serious issue (has been a drawback in previous years).
- In the past, training development in the RNLAF has been done mostly bottom up (instructors develop their own material). The interviewee indicates that this is not necessarily a bad thing., but from an educational design point of view standardisation and structured training development such as ISD or 4CID are recently coming more in focus in projects such as HIVO and ATTP/MTTP.

Bottlenecks in TT development at the RNLAF:
- Effort by people (time) and financial resources to develop TT.
- SME time (content expertise) and training development time.

What should change on the side of IMAT to make it applicable in the RNLAF:
- IMAT concept is good: how to re-use existing content and information. This could lead to a cost reduction in TT development.

Interesting questions to be answered:
- How does IMAT relate to ADL SCORM? Can IMAT be used to add metadata to SCORM compliant content?
- To what degree does the IMAT metadata set derived from the IMAT taxonomies differ or map with the SCORM metadata set?
- To what extent is it possible to connect IMAT (fragments) to the SCO-Generator? Is it for instance possible to extract IMAT fragments from the database and use them in the SCO-Generator to create instructional material, or in other words: could IMAT work as a pre-authoring system for the use of the SCO-Generator?
- Another interesting question (also outside IMAT) is the question to which extent metadata can be generated automatically for learning objects, instead of manual creation of a metadata set. (the interviewee gives the example that KPN currently estimates that 80% of training development time is spent on the (manual) creation of metadata for electronic content).

What should change on the side of the organisation to make IMAT applicable in the RNLAF:
- TT developers should be trained to be able to work with IMAT tools.

Educational Factors

General

Important developments in RNLAF:
- Competence-based training and education.
- Connect learning objects to competencies.

- Open versus closed learning environments.

Importance of TT:
TT is the core of training and education within the RNLAF.

TT Characteristics:
- Aimed at the training and education of functions, and therefore on the skills of persons to perform a function.
- Students: there is a large variability in students, due to a large set of functions and scales within the RNLAF. In general the initial educational level of new technicians in the RNLAF is declining .
- Instructors in TT have an MBO degree in a technical field, strong domain expertise (maintenance experience) and additional education as instructor.
- Instructors are also TT developers (usually two roles in one person).

Challenges in TT:
- In the past TT has been designed with a strong knowledge-based focus. Therefore the transfer of training to practice was a large step (students would have a broad and depth knowledge, but no training in how to use this knowledge in practice during maintenance).
- At the moment there is a shift in the RNLAF to competence-based training, JE, JIT, and learning tasks. Focus during initial training should lie more on skills, both cognitive and psycho-motoric skills.

Design
Relevant TT characteristics to consider in the design of TT at the RNLAF:
- Focus on skills and design of learning tasks.
- "Leerstofdomein afbakening" (defining subject limits) is an important issue.

Bottlenecks in TT design:
- Capacity and effort of people to create training material.
- Moments of choice in the instructional design process are subjective (there is no single good solution, there are multiple "good ways" in an ISD process).

TT design:
- The RNLAF aims at more structured and standard support (as for instance provided in the SCO-Generator) during the development of training (generic solutions, standardisation)
- The interviewee does not yet foresee more adaptive learning solutions for students. It depends on the organisation's choice between a docent versus a student centred learning solution. And although from a student perspective (certainly at school) a certain level of adaptivity is very desirable, (e.g. self study and learning material aimed at various learning styles). The real issue is how to prevent grow of a large variety of training types, resulting in content

management problems (time consuming and costly). In the end, the interviewee foresees a middle of the road scenario.

Design support:
- There is a need for didactic support during the training design and development phase, and this is besides IMAT (in the Instructional Scenarios Tool) also addressed in the SCO-Generator project.
- The RNLAF thinks it is important to provide instructors (training developers) with structured support during TT design and development, e.g. through the development of EPSS kind of solutions.
- The RNLAF wants to give instructors freedom to develop training material according to their own expertise to a certain level the (freedom within limits). However, freedom always will be limited due to organisational choices e.g. for certain development tools, platform or learning solution (ATTP example: this is not a facultative learning solution). The real question is to which extent an organisation should allow individual freedom and at which point the organisation determines the development process (e.g. central content management).

Outsourcing of TT development:
- Yes and no. Due to lack of in-house expertise outsourcing is sometimes the only solution.
- Outsourcing is only possible at certain levels, and always requires a large involvement of RNLAF SME expertise during the development phase.
- Eventually a mix of in house development and outsourcing will take place. The IMAT tools could assist in the pre-authoring process (to create and retrieve fragments) for CBT material, which can be developed in house. More complex training solutions, such as simulation, will probably require outsourcing due to a lack of in-house expertise.

Advanced training solutions

Important developments in the area of advanced training solutions:
- E-Learning: ADL-SCORM
- Challenges: How to set up TT (with e-learning) in such way that initial training at the KMSL and training on the job "match".
- Simulation Based Training: ATTP/MTTP
- Challenges: How to develop a coherent training system instead of single simulation components? (In the MTTP project this is the "showcase question", the 4CID model is used in this project as didactic guidance in giving learning means a certain function in the educational process)
- Lessons learned in ATTP/MTTP project:
  - Pre-phase is extremely important: think about and define what you want to have.
  - There are many opinions (and differences in expectations) on the format of the end product

- It is difficult to set up good specifications (they are not always clear to developers and can lead to differences in expectations of the product).
- Tools: the development of tools (advanced training solutions) often is not the most difficult part, but providing and having the didactic know-how how to use them in training is a challenge. Consequently, the learning means (such as COO) sometimes are not as used in the way as was meant by the instructional design).

TT Curriculum

Relevant developments considering the definition of the TT curriculum:

- Blended learning (ILT, e-learning, simulation based training, training on the job)
- Role of IMAT: IMAT can act as bridge between the delivery of assets for basic knowledge and JIT. (IMAT can help in the easy disclosure of information, act as a pre-authoring system delivering 'semi-finished goods': raw material suitable for the creation of training material).

Centralisation of TT:

The initial part of the TT will be centralised at the KMSL and the rest of the training will be given at a "leerbedrijf" (business schools) at the different RNLAF bases.

Outsourcing of training:

This certainly is a possibility, but many scenarios are possible in the future (examples of EPAF countries distributing or specialising in parts of F16 maintenance training or in the future JSF training).

Up to date training material:

Up to date training material is very important, but it is better to speak in terms of valid training material (this is not necessarily the same as up to date material). Valid training material can also comprise a generic training module, which explains for instance the principles and working of a GPS without having the latest documentation or exact version of the GPS in a F16.

Training Effectiveness:

The key to efficiency is "doeltreffendheid/effectiveness". Just enough training is an important feature here. Students need to learn what they need to know for competent performance (rather than what is nice to know).

Technical factors

Technical developments of relevance:
- IETM implementation in the RNLAF.

Technical requirement's for IMAT:
- Availability of electronic content

Ontology concept:
The interviewee does not see any direct uses of the ontology concept outside of IMAT. The concept of putting tags on fragments however is important and IMAT provides solutions for that. However, the interviewee foresees that the RNLAF will start working with a small set of metadata derived from IMS (instead of a rich set of metadata in IMAT). It is important to determine whether the effort to foresee fragments with metadata is worthy of the reusability factor. Maybe it is far more interesting to think about defining a set of metadata as small as possible to guarantee reusability of content.

Organisation/infrastructure
- Data security is not an issue as long as IMAT operates within the confidential RNLAF infrastructure (KLUIM). This will be different as soon as online or wireless communication is used as solution (interviewee does not foresee this kind of communication necessary for the use of IMAT in the RNLAF).
- Infrastructure: According to the interviewee KLUIM is from a technical perspective (bandwidth) adapted for e-learning solutions, but from an organisational perspective many complications are foreseen due to administrative rules (and the fact that KLUIM is maintained by a separate organisation: the DTO). Many solutions, such as ADSL or wireless communication are not allowed within the confidential network of the RNLAF.

Technology level
The RNLAF is progressive in its level of technology, certainly in areas where people work with advanced weapon systems, advanced technology is commonly used both in maintenance and training.

RNLAF Supplements
The interviewee indicates that the RNLAF supplements fall under the jurisdiction of another department of the RNLAF (DM) and therefore holds no opinion on this matter.

Domain
- The RNLAF domain is dynamic (e.g. F16), but changes and updates are predictable.
- The RNLAF domains differ (e.g. Apache is a digital system and the F16 is an analogue system)

- Domain analysis is in theory worthwhile, in practice probably not. A lot of domain knowledge is for instance available with suppliers of a system or other airforces. One could for instance take the approach to see which knowledge can be borrowed or used from other parties instead of putting lots of effort (time consuming, high costs) in the pre-authoring process (including a domain analysis), of course all within the limits of safety.

Organisational factors

General
- Training is strongly function-related.
- A defence organisation is very structured, and has to follow many rules and laws (also outside the defence world, e.g. JAR standards).
- Therefore (probably) less room is foreseen for open learning environments (comparison with the Belastingdienst, tax authorities that follow the path of open learning environments). In an open learning environment IMAT tools could for instance be used as JIT tools by students. In the RNLAF context (probably a closed learning environment) IMAT tools will act as pre-authoring tools in the training design and development phase.

Personnel availability:
The RNLAF is a relatively small defence organisation, with a wide range of weapon systems functions and tasks and therefore personnel availability is a serious problem in all functions (Instructors/Developers, OTT, and Maintenance Specialists).

Consequences of budget cuts:
- More tasks then people (scarcity of personnel) in the RNLAF.
- Personnel reductions.

IETM
- The IETM implementation will probably lead to a stronger focus on training on the job and EPSS approaches in training, given the prerequisite that a person has the basic knowledge skills (received during initial training). The interviewee indicates that in general he foresees a division in specialists between a large group of specialists focusing on daily maintenance, and a small group of "troubleshooting" specialists. EPSS and coaching are two elements of support, which can be provided during maintenance.
- In the future (e.g. JSF) IETMs will be connected with systems on board aircraft providing new ways of assistance during maintenance.
- Interviewee sees IETM and IMAT as two different solutions for two different phases. IMAT can provide support during training development and IETMs can provide support during maintenance and maybe act as JIT solution on the job.

- Another question is to which extent IETMs can act as training material, and which steps writers of IETMs undertake to create "real" training material based upon the IETM.

Standards
JAR 146 and 166 hold strong implications for TT for aircraft maintenance (e.g. up to date training material)

International/ local factors
- Internationalisation grows certainly between countries with the same weapon systems (e.g. EPAF countries conduct maintenance (and other related issues such as logistics) in the same way, so that during NATO missions technicians between the airforces can work on each others F16's)
- Local factors play a role to a certain extent, but F16systems maintenance is F16systems maintenance, as much in the Netherlands as in Belgium or the USA.

Summary
New factors/ issues that came up in the interview:
- New approaches in TT:
  - TT redevelopment
  - Competency based training
  - 4CID model
  - Didactic support during development (e.g. SCO-Generator)
  - TT design (support)
- ICT organisation, laws and rules concerning KLUIM hold strong restrictions for the implementation of e- learning and IMAT solutions.
- Reduction of personnel
- Organisation culture
- Effort
- Efficiency
- Costs
- An asset is an instructional fragment (and not a fragment from a technical manual)

New questions that came up during the interview:
- How do you get what you want (simulation based training, but also in IMAT)?
- What does it take (effort) to transform technical documentation into training material with IMAT?
- Is the IMAT pre-authoring process worth the costs, time and effort (in a certain domain)?
- What is the added value of ontology development?
- Could a smaller set of metadata do the job?
- Can IMAT deliver ADL SCORM compliant content (or add metadata)?

REPORT DOCUMENTATION PAGE
(MOD-NL)

1. DEFENCE REPORT NO (MOD-NL)	2. RECIPIENT'S ACCESSION NO	3. PERFORMING ORGANISATION REPORT NO
TD2005-0302	-	TNO-DV1 2004 A169
4. PROJECT/TASK/WORK UNIT NO	**5. CONTRACT NO**	**6. REPORT DATE**
015.30801	-	September 2005
7. NUMBER OF PAGES	**8. NUMBER OF REFERENCES**	**9. TYPE OF REPORT AND DATES COVERED**
114 (incl appendices, excl RDP & distribution list)	27	Final

10. TITLE AND SUBTITLE

The role of IMAT solutions for training development at the Royal Netherlands Air Force.

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12. PERFORMING ORGANISATION NAME(S) AND ADDRESS(ES)

TNO Defence, Security and Safety, PO Box 96864, 2509 JG The Hague, The Netherlands
Oude Waalsdorperweg 63, The Hague, The Netherlands

13. SPONSORING AGENCY NAME(S) AND ADDRESS(ES)

-

14. SUPPLEMENTARY NOTES

The classification designation Ongerubriceerd is equivalent to Unclassified, Stg. Confidentieel is equivalent to Confidential and Stg. Geheim is equivalent to Secret.

15. ABSTRACT (MAXIMUM 200 WORDS (1044 BYTE))

Integrating Manuals and Training (IMAT) tools, developed in the European Esprit Project 29175, provide an advanced set of prototype tools that have been developed for the effective and efficient reuse of (electronic) technical manuals for the development of training material. To investigate the applicability of IMAT tools in the RNLAF the following research activities were conducted: analysis of the IMAT concept and tools, analysis of educational, organisational and technology (ETO) factors of influence in the RNLAF, modeling, definition of various user scenarios, interviews, expert reviews and a comparison of methods used for adding metadata in IMAT compared to the ADL-SCORM standard used by the RNLAF. Based upon the results from these research activities it was concluded that the IMAT tools can be a valuable contribution to training (development) in the RNLAF. The tools, however, are still prototypes and need to be developed further to become fully operational. The applicability of the IMAT concept depends on the choices the RNLAF will make regarding the implementation of electronic technical manuals, the development of (electronic) training material, the type and size of the training domain(s), etc. The research resulted in a set of requirements for successful IMAT implementation.

16. DESCRIPTORS	IDENTIFIERS
Instructional System Design	Training
Ontology	Standardization
Tool	

17a. SECURITY CLASSIFICATION (OF REPORT)	17b. SECURITY CLASSIFICATION (OF PAGE)	17c. SECURITY CLASSIFICATION (OF ABSTRACT)
Ongerubriceerd	Ongerubriceerd	Ongerubriceerd

18. DISTRIBUTION AVAILABILITY STATEMENT	17d. SECURITY CLASSIFICATION (OF TITLES)
Unlimited	Ongerubriceerd

Distributielijst

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2. DR&D
3. Dr. W.F.S. Hylkema, HKKLu/KLu
4. Kol Drs. A.C.J. Bernards, HKKLu/KLu
5. Kol Drs. R.H. Kramer, KMSL/KLu
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17. Documentatie TNO Defensie en Veiligheid
18. Reserve

Distributie managementuittreksel & distributielijst

1× TNO Defensie en Veiligheid, Algemeen directeur,
TNO Defensie en Veiligheid, Directeur Operaties,
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MIVD / AAR / HBMT

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